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ON THE BIOLOGY AND FISHERY OF 'CHOO PARAI'-
LAROIDES LEPTOLEPIS (Cuvier and Valenciennes)

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K.N. Tandon.

Certified that Shri Kewal Krishan Tandon, M.Sc.(Hons.) carried out his research work under my supervision in the Central Marine Fisheries Research Station, Mandapam Camp, South India. He has completed his work on the biology and fishery of 'Choo parai'- Selaroides leptolepis (Cuvier and Valenciennes) and this thesis has not been submitted so far to any other University.

10/2/60

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PREFACE

India is primarily an agricultural country and the fisheries play an important role in her economy. India has a long coast line of nearly 3000 miles and the waters surrounding her are rich in fishery resources. For the proper management and exploitation of these resources, information on the various aspects of the biology -- food and feeding habits, size at first maturity, the number of ova spawned by each fish in a season(s), spawning grounds, larval history, spawning season(s), age and growth of the fish, types of the crafts and gears used, and the populations existing in a particular area -- of commercially important species of fish is very essential. It is also imperative to know the various size and age groups constituting the fishery. Study of each of these aspects depends upon the regular collection of the data and their analyses.

The information so far available on the biology of the marine fishes is meagre and in view of the present emphasis on the exploitation of the marine resources it has become necessary to study the commercially important fishes in detail. Therefore, with a view to contributing to our knowledge of the biology of these fishes and their bearing on the fishery, the present work on <u>Selaroides</u>

leptolepis, a common carangid of the Palk Bay and the Gulf of Mannar in this area, the existing knowledge about which was very little, was taken up. As a result of this work carried out I have been able to collect information on the general conditions of the fishery, populations, food and feeding habits, length-weight relationship, reproduction, sex ratio and age and growth of the fish. The report is mainly based on the commercial catches and is presented in as detailed a manner as possible.

I am extremely thankful to Dr. N.K. Panikkar, Fisheries Development Adviser to the Government of India (the then Chief Research Officer), for kindly suggesting this problem. The work was done at the Central Marine Fisheries Research Station during the tenure of a Senior Research Scholarship from the Ministry of Education, Government of India. I am grateful to the Ministry for the award of the Scholarship. My heartiest thanks are due to Dr. S. Jones, D.Sc.,F.N.G.S.,F.A.Sc.,F.Z.S.I., Chief Research Officer, and Dr. R. Raghu Prasad, M.Sc.,Ph.D.,F.A.Sc.,F.Z.S.I., Senior Research Officer, Central Marine Fisheries Research Station, Mandapam Camp for their kind help, suggestions, criticism, their keen interest in my work and for going through the manuscript and the thesis. My thanks are also due to Mr. S.K. Banerji, M.A., Research Officer for guiding me in the statistical calculations and his useful suggestions from time to time. To my colleague, Mr. M. Subrahmanyam, I am indebted for having accompanied me during most of my collection tours. Lastly, I thank the crew of M.L. 'Sagitta' and M.L. 'Choodai' and the staff of the Central Marine Fisheries Research Station in general who were very cordial and considerate towards me.

Kewal Krishan Tandon

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SECTION I

CHAPTER 1

INTRODUCTION

Very little work has been done on the life history of carangids of the Indian waters. The author, therefore, took up in May 1957 the study of the biology and fishery of one of the important carangids - Selaroides leptolepis (Cuvier and Valenciennes), locally known as 'Choo parai', in the Gulf of Mannar and the Palk Bay.

Carangids are wide-spread in the Indo-Pacific region, and their importance in the fishery resources of India is not negligible as they constitute about 2 per cent of the total annual marine catch. Although this species is common from Visakhapatnam on the east coast to Vizhingam on the west coast of India, it is known to constitute a fishery only at Madras on the east coast and Vizhingam on the west coast in addition to the local one. Krishnamurthi (1957) rightly stressed the importance of Caranx leptolepis among the carangids in the fishery resources of the Rameswaram Island.

The observations made on the biology of carangids of the Indo-Pacific and the European waters by the earlier workers are of great importance. To mention a few, Delsman (1926) and De Jong (1940) described the eggs and spawning periodicities respectively of Caranx species from the Java Sea. Devanesan and Chidambaram (1941), Devanesan and Vardarajan (1942) and Panikkar and Nair (1945) gave an account of the Caranx eggs from West Hill and Madras. Chacko (1949) and Mahadevan (1950) described the food of Indian horse-mackerel from the Gulf of Mannar and the Madras waters respectively. Tham Ah Kow (1950) gave an account of the food and feeding habits of Caranx species from the Singapore Straits. Jones (1951) published a bibliography of the breeding habits and development of estuarine and marine fishes and in it he gave a complete list of references on the work done on the Indian carangids. Bapat and Prasad (1952) described some of the developmental stages of Caranx kalla from the Palk Bay and Nair (1952) gave an account of the carangid eggs and larvae occurring in the Madras plankton. Datar (1954) and Kuthalingam (1955 b) described the food of C. rottleri and C. djedaba from Bombay and Madras respectively. Bapat (1955) gave an account of various types of carangid eggs present in the Palk Bay and the Gulf of Mannar. Chacko and Mathew (1956) gave short accounts of the gross biological features of eleven species of horse-mackerel from the Malabar coast. Prabhu (1956) described the spawning periodicity of Caranx (Selaroides) leptolepis from the Gulf of Mannar. Vijayaraghavan (1957) gave a detailed account of the eggs and larvae of Decapterus russelli and Caranx species from Madras. Aoyama (1958) described the amount of food taken by *Trachurus japonicus*. Hatanaka and Murakawa (1958) and Uchida *et al* (1958), described the food, spawning and early life history of amber fish - *Seriola quinqueradiata* - from Japan. Uchida (1958) also gave an account of the larvae and juvenile of Japanese carangids (*Trachurus japonicus*, *Seriola aureovittata*, *S. quinqueradiata* and *S. purpurascens*).

Beyond the limits of the Indo-Pacific region, the following works merit special mention.

Clark (1914) gave a general account of the larval and post-larval forms of *Caranx trachurus* from Plymouth. Lebour (1918, 1920) described the food of *Caranx trachurus* (larval and post-larval forms) from the Cawsand Bay. Hildebrand and Cable(1930) gave description of the development of *Decapterus punctatus* and *Seriola dumerilli* from Beaufort, N.C. Breder (1951) described the spawning behaviour of *Caranx sexfasciatus*. Williams (1956) gave short accounts of certain aspects of the biology of *Caranx* species from East Africa. McKenney *et al* (1958) gave an account of the early life history and food of the larval *Caranx crysos* from the Caribbean Sea.

This report deals with the biology and fishery of *Selaroides leptolepis* and in addition to it a brief account of its taxonomic position is also given.

CHAPTER 2

MATERIAL AND METHODS

Material for the studies on Selaroides leptolepis (Photograph 1) was collected from Thangachimadam (Pungudi) and Rameswaram (Verkut) on the Palk Bay and Rameswaram Road and Pudumadam on the Gulf of Mannar (Plate 1, Fig. 1). The fish landing centres are situated at distances varying from 2 to 6 kilometers from the nearest railway station to which they are connected by sandy tracts. The fishing is carried out at depths varying from 10 to 15 meters.

The shore is rocky off Thangachimadam and coral reefs extend for at least a mile into the sea. Consequently the fishermen have to go far away from the shore for fishing and usually they cover a distance of 8 to 9 kilometers. Bag-nets, operated from catamarans, are used for fishing which is carried out between 12.30 A.M. and 4.30 A.M. at this place. The material was collected at about 6 A.M.

The shore at Rameswaram and Rameswaram Road is sandy, whereas at Pudumadam it is partly rocky and partly sandy. As a result of the sandy nature of the shore, shore-seines are operated at these places from the Tuticorin type of boats. These operations are carried out during day as well as night. Material from Rameswaram could not be collected throughout the entire season due to irregular timings and great fluctuations in fishery at this centre.

The fishing operations last from November to March in the Gulf of Mannar and April to October in the Palk Bay due to the North-East and South-West monsoons respectively. Thus, according to the fishing season, the material was collected weekly from the above fishing centres except on certain occasions when specimens were available only fortnightly or sometimes monthly. A random sample of 30 to 50 fish was brought to the laboratory each time for complete analysis. Each fish was examined in the fresh state for its length, weight and stage of maturity, except on two occasions when the length and stage of maturity were recorded from the preserved material. The fresh fish after preliminary examination were numbered, dated and preserved in 5 per cent formalin for further studies. The fork length -- taken from the tip of the lower jaw to the tip of the shortest fin ray in the caudal fork -- was used for all calculations. Measurements were taken in metric units.

Details of methods used are described in the relevant sections.

CHAPTER 3

TAXONOMIC POSITION AND DISTRIBUTION

Taxonomic position.

Lacépède (1802) described *Caranx* for the first time with the following characters: "Deux nageoires dorsales; point de petites nageoires audessus ni au-dessous de la queue; les côtés de la queue relevés longitudinalement en carène, ou une petite nageoire composée de deux aiguillons et d'une membrane, au-devant de la nageoire de l' anus."

Fishes with the above characters were grouped under the genus *Caranx* and treated under the family Scomberoidei by Cuvier (1817 ?), Müller (1844) and Cantor (1849); the latter author, however, labelled the family as Scombroidae as opposed to Scomberoidei of Cuvier (*op. cit.*) and Müller (*op. cit.*).

The presence of more than 24 vertebrae in the Scombroid and only 24 in the Carangoid fishes led Günther (1860) to separate the two, the former in the family Scombridae and the latter in Carangidae. *Naucrates*, a carangid, has 26 vertebrae, but comparison of other characters shows that it is more closely related to carangids than to scombroids. Günther (*op. cit.*) remarked: "Several authors have also distinguished a family of Carangidae; but if they have defined it at all, they have applied characters very different from those given above, and have not paid attention to the structure of the skeleton." Gill (1882) commenting on this statement emphasized that Günther had withheld all definite information and means of verification of his statement. It may further be noticed from Gill's account that the name "Carangidae" suggested by Agassiz was merely an orthographical substitute for subfamily names of Caranginae.

Family Carangidae is, thus, distinguished from the Scombridae by the presence of 24 (10+14) vertebrae. The body is moderately elongated and more or less compressed. The first dorsal is spinous, the spines are connected by membranes, and lodged in a groove. It is preceded by a procumbent spine which may be partly embeded in the skin. The second dorsal has one spine and number of soft rays and so has the anal, the latter preceded by a more or less detached and distinct finlet of two spines. The posterior rays of the soft dorsal and anal are sometimes detached. Dentition is feeble, when complete, teeth are present on both the jaws, vomers, palatines and tongue. There are seven branchiostegals, and four gills. Pseudobranchiae are also present. Small thin cycloid scales may be present or absent, when present those on the lateral line are sometimes enlarged and spiny.

Day (1876, 1889) placed the family Carangidae under the group Cotto-scombriformes of the order Acanthopterygii.

Regan (1913) described Carangidae under the suborder Percoidea of the order Percomorphi and referred the Scombroids to a separate suborder, the Scombroidei. This is at variance with many other authors who are inclined to the belief that there is a closer relationship between the Carangidae and Scombridae. Starks, Jordan and Evermann, Boulenger and Gregory as quoted by Merriman (1943) placed these two families in the same group in the Percomorph order -- a group to which they gave the names Scombroidei and Scombriformes respectively.

Jordan (1923) placed the family Carangidae under the order Percomorphi.

Weber and de Beaufort (1931) following Regan's (op. cit.) classification created a group called Carangi and treated the family Carangidae under this group. They divided the family into four subfamilies viz., Caranginae, Chorineminae, Trachinotinae and Seriolinae. The genus Caranx was subsequently listed under subfamily Caranginae. The Caranginae includes six genera viz., Megalaspis, Decapterus, Atropus, Caranx, Ulua and Alectis, which can be differentiated from each other by the following characters:

A. One or more finlets behind soft dorsal and anal.

1. A single finlet behind soft dorsal and anal - Decapterus

2. Several finlets behind soft dorsal and anal - Megalaspis

B. No finlet behind soft dorsal and anal.

i. VII-VIII dorsal spines connected by membranes, scales apparent, none of the rays of soft dorsal and anal equalling the length of body.

3. A deep median groove in the abdomen, containing vent and detached anal spines receiving the ventrals - Atropus

4. Gill rakers of moderate length and normal shape - Caranx

5. Gill rakers extremely long reaching into mouth and feather-like in shape - Ulua

ii. Dorsal spines less than seven, not connected by membrane. Scales not apparent, embeded in the skin. Anterior dorsal and anal rays equalling length of body - Alectis

The fishes possessing the characters of the genus Caranx were further divided into sub-genera. Weber and de Beaufort, thus, listed six such sub-genera viz., Selar, Carangoides, Caranx, Uraspis, Selaroides and Gnathanodon.

Thus, if dentition is complete and teeth on lower jaw uniseriate, upper jaw also uniseriate, often pluriseriate anteriorly, it is Selar and when in both jaws teeth are pluriseriate anteriorly and in some exceptional cases outer teeth are stronger, it is Carangoides. Dentition when complete and teeth are villiform in upper jaw with an outer series of strong ones and 2 or 4 more or less caniniform anteriorly, it is Caranx. When teeth are absent from the vomer, palatines and tongue but acute curved teeth are present in upper jaw in two, in lower jaw posteriorly in one series, or in both jaws in a single or in two series, it is Uraspis. Teeth when present in a single series on lower jaw and are rudimentary on tongue, it is Selaroides and altogether absent in Gnathanodon.

Roxas and Agco (1941) followed Weber and de Beaufort in the classification of the genus Caranx from the Philippine waters.

Berg (1947) described the family Carangidae under the superfamily Percoidae and suborder Percoidei of the order Perciformes (Acanthopterygii, Percomorphi). In the classification of suborder Percoidei he followed Regan's work.

Munro (1955) followed Berg for the classification of the family Carangidae. He raised all the sub-genera of

Weber and de Beaufort to the status of genera. In the present study *Selaroides* is treated as a genus.

SELAROIDES:

The genus *Selaroides* was created by Bleeker in 1851 on the basis of dentition which was distinguished from the *Caranx* like fishes by the presence of a single series of very small teeth on the lower jaw, and rudimentary ones on the tongue. They are absent on upper jaw, vomers and palatines. This genus is represented by a single species, *leptolepis*. The first specimen of this species was passed on by Kuhl and Hasselt from the museum of Pays-Bas from Java to Cuvier and Valenciennes in 1833 and thus described as *Caranx leptolepis*. In the same year, when Cuvier and Valenciennes received a specimen from Mertens, they named it *Caranx mertensii* (because of the absence of opercular spot) though this resembled very much to *Caranx leptolepis* labelled earlier by those authors. Cantor (1849) described it as *Caranx leptolepis*, Kuhl and van Hasselt.

In 1851 when Bleeker created the genus *Selaroides* he labelled the species *leptolepis*, as *Selaroides leptolepis* Blkr. which is an equivalent of *Caranx leptolepis* K. v H.

On the basis of the present observations *Selaroides leptolepis* has the following characters:

It has a laterally compressed body with the lower jaw somewhat prominent pointing upwards and is provided with a single row of very minute teeth while the upper jaw is protrusible into a tube and is devoid of teeth. Rudimentary teeth are present on the tongue, they are, however, absent on the vomers, and palatines. Each eye is provided with a broad posterior and a narrow anterior adipose eyelid. Small thin cycloid scales are present on cheeks, pre-operculum, top of operculum, temporal and occipital regions and on the body. Lateral line is arched anteriorly and becomes straight below 8 to 10th dorsal ray. The scales on the straight portion become prominent and are described as scutes. There are two dorsals, the first is spinous and is preceded by a procumbent spine embedded partly in the skin. The spines of first dorsal are eight in number, and are connected by thin membrane and lodged in a groove. The second dorsal has one spine and 21 to 27 rays. The anal fin has two anal spines separated and one spine and 18 to 23 rays. The pectorals are longer than the head and each consists of one spine and 19 rays. Ventrals are thoracic and scarcely reach the pre-anal spines. Each ventral has one spine and 5 rays. The caudal is forked and the lobes point outwards showing their acute nature. A golden yellow band extending from above the eye to the upper edge of the tail is present on both sides. Similarly a black spot is also present on the operculum. The colour in the fresh state is greenish above and silvery below. There are 24 (10+14) vertebrae.

Dentition has been described differently by various workers. Thus, Cantor (1849) described the dentition as excessively minute in both jaws so as to be barely perceptible to the touch.

Day (1876) gave two different statements regarding the dentition. On page 213 of Vol.1 (Fishes of India) he described: "Teeth are present in a single row in both jaws" and on page 225 of the same volume "Teeth -- fine ones in the anterior portion of the lower jaw, none on the upper, the vomer or palate: a fine band on the tongue."

In 1877 Alleyne and Macleay described Caranx leptolepis as Caranx cheverti (presumably on the basis of anal and dorsal rays) from Katow, New Guinea and mentioned the presence of teeth on vomer, but their conclusion is based on a single specimen.

Fowler (1927) while describing Selaroides leptolepis as Gnathanodon leptolepis (Cuv.) delineated the dentition as "row of minute teeth on each jaw, none on palate."

The following is a description of meristic counts described by various authors (D=Dorsals, A=Anal, P=Pectorals, V=Ventrals, C=Caudal, Br=Branchiostegal rays, L.lat=Scutes on the lateral line).

Cuv. & Val. (1833) Caranx leptolepis et mertensii

D.VIII;I,25. A.II,I,22. etc.

Cantor (1849) Caranx leptolepis, Kuhl & van Hasselt

D.VIII;I, 25-26. A.II,I,22-23. P.20. V.I,5.

C.17 6/6. Br.VII.

Günther (1860) Caranx leptolepis et mertensii, Cuv. & Val.

D.VIII;I,24-26. A.II,I,20-23. L.lat.25-30.

Day (1876) Caranx leptolepis et mertensii, Cuv. & Val.

D.VIII;I,24-26. A.II,I,21. P.20. V.I,5. C.17.

L.lat.24-28. Br.VII.

Alleyne and Macleay (1877) Caranx cheverti

D.VIII;I,26. A.II,I,23.

Day (1889) Caranx leptolepis et mertensii, Cuv. & Val.

D.VIII;I,24-26. A.II,I,21. P.20. V.I,5. C.17. L.lat.24-28.

Fowler (1927) Gnathanodon leptolepis (Cuv.)

D.VIII;I,24. A.II,I,21.

Weber and de Beaufort (1931) Caranx (Selaroides) leptolepis, Cuv. & Val.

D.VIII;I,25. A.II,I,20.

Roxas & Agco (1941) Caranx (Selaroides) leptolepis, Cuv. & Val.

D.VIII;I,24-25. A.II,I,21. P.I,19. V.I,5. C.20.

Munro (1955) Selaroides leptolepis (Cuv.)

D.VIII;I,25. A.II,I,20. L.lat.25-30.

A good deal of diversity is found in the meristic counts especially in regard to rays of second dorsal and anal. The present author who has examined a large number of specimens (681) of Selaroides leptolepis (Cuv. & Val.) found the range of meristic counts as follows (the last dorsal and anal rays were counted as one each).

D.VIII;I,21-27 (with one procumbent spine). A.II, I,18-23. V.I,5. Br.VII.

The taxonomic position is given as:

Class	= Teleostomi
Subclass	= Actinopterygii
Order	= Perciformes
Suborder	= Percoidei
Superfamily	= Percoidae
Family	= Carangidae
Genus	= Selaroides
Species	= leptolepis

Distribution and synonyms.

The genus Selaroides is represented by a single species, leptolepis and is fairly common in the tropical and the adjacent Seas of the temperate zone. It is a marine fish. In India, it has been recorded from Vizhingam (west coast), Tuticorin, Mandapam, Kilakarai, Periapatnam, Pudumadam, Vedalai, Theedai, Panaikulam, Devipatnam, Rameswaram Island, Madras and the areas adjoining it and Visakhapatnam (east coast).

A detailed description of the synonyms and the distribution of this species, as described by different authors, is given below. The world distribution of this species is shown in Plate 1, Fig. 2.

Synonym	Author & year	Journal	Distribution
Caranx leptolepis.	Cuvier and Valenciennes, 1833.	Hist.Nat.Poissons, vol.9, p.48.	Java.
Caranx mertensii.	Cuvier and Valenciennes, 1833.	*Ibid.*, p.48.	Manila, Luzon.
Caranx leptolepis.	Bleeker*, 1845.	Nat.Geneesk. Arch.Ned.-Ind., vol.2, p.517.	Batavia, Java.
	Cantor, 1849.	J.Asiat.Soc. Beng., vol.18, p.1108.	Sea of Pinang, Singapore, Java, Manila.
	Bleeker**, 1851.	Nat.Tijdschr. Ned.Ind., vol.1, p.346.	--
	Günther, 1860.	Cat.Fishes British Mus., vol.2, p.440.	Malayan Peninsula, Australia.
	Day, 1876.	Fishes of India, vol.1, p.225.	Madras, Sea of India to the Malay Archipelago.
	Macleay**, 1881.	Descr.Cat.Aust. Fishes, Sydney, vol.1, p.168.	--
	Boulenger**, 1889.	Proc.zool.Soc. Lond., p.240.	--

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Day, 1889.	Fauna of British India, vol.2, p.167.	Seas of India to the Malay Archipelago and Australia.
Elera**, 1895.	Catalogo Systematico de toda la Fauna de Filipinas. Vertebrados, vol.1, Peces, p.510.	--
Duncker**, 1904.	Mitt.Naturh. Mus.Humburg, vol.21, p.156.	--
Jordan and Richardson, 1907.	Bull.U.S.Bur. Fish., vol.27, p.250.	Cavite, Cavite Province, Luzon.
Been and Weed**, 1912.	Proc.U.S.nat. Mus., vol.42, p.599.	--
Weber**, 1913.	Die Fische der Siboga Expedition, Leiden, p.397.	--
Fowler*, 1918.	Copeia, No.58, p.63.	Philippines.
McCulloch**, 1924-26.	Mem.Queens Mus., No.8, p.72.	--
McCulloch*, 1929.	Mem.Aust.Mus., 5, p.188.	Queensland; New Guinea; East Indies; Philippines.
Umali*, 1936.	Edible Fishes Manila, p.112.	Manila Bay and the Visayas.
Villadolid*, 1937.	Philipp.J.Sci., vol.63, p.215.	Balayan Bay, Batangas Province, Luzon.
Umali*, 1937.	<u>Ibid.</u>, p.235.	San Miguel Bay, Luzon.
Fowler, 1938.	Proc.Acad.nat.Sci. Philad., Bishop Mus., Fish.Bull. No.1, p.109.	Penang, Malay Peninsula, Singapore.

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	Domantay, 1940.	Philipp.J.Sci., vol.71, p.100.	Zamboanga Province, Mindanao.
	Domantay*, 1940.	*Ibid*., vol.72, p.379.	Margosatubig, Zamboanga Province, Mindanao.
	Blegvad, 1944.	Dan.Sci.Invest. Iran,Part III, p.99.	Iranian Gulf, North Indian Ocean, Malay Archipelago, China, Philippines, Queensland.
	Krishnamurthi, 1957.	Indian J. Fish., vol.4, No.2, p.244.	Rameswaram Island, India.
Leptaspis leptolepis.	Bleeker*, 1852.	Verh.Bat.Gen., vol.24, Makreel. Viss., pp.71 and 87.	Sunda-Moluccan Archipelago.
	Oshima*, 1925.	Philipp.J.Sci., vol.26, p.387.	Keelung, Formosa; after Day.
Caranx cheverti.	Alleyne and Macleay, 1877.	Proc.Linn.Soc. N.S.W., vol.1, p.324.	Katow, New Guinea.
	Macleay**, 1881.	Descr.Cat.Aust. Fishes, Sydney, vol.1, p.169.	--
Caranx procaranx.	de Vis*, 1884.	Proc.Linn.Soc. N.S.W., vol.9, p.540.	Cape York, Queensland.
Carangus leptolepis.	Jordan and Evermann**, 1903.	Proc.U.S.nat. Mus., vol.25, p.337.	--
Gnathanodon leptolepis.	Fowler, 1927.	Proc.Acad.nat. Sci.Philad., vol.79, p.271.	Orion, Bataan Province, Luzon, Philippines.
	Fowler**, 1928.	Mem.B.P. Bishop Mus., No.10, p.150.	--
Caranx (Selaroides) leptolepis.	Wakiya*, 1924.	Ann.Carnegie Mus., vol.15, p.208.	Riukiu Islands; Formosa.

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	Weber and de Beaufort, 1931.	Fishes Indo-Australian Archipelago, vol.6, p.262.	Singapore; Pinang; Sumatra (Telok betong); Java (Batavia); Flores!; Celebes (Makassar!, Bonthain, Bulukomba, Badjoa); Ambon; South Coast New Guinea. -- Muscat, British India, Ceylon, Tonkin, China (Swatow), Riu Kiu, Formosa, Philippines, Australia (Queensland, Cape York).
	Roxas and Agco, 1941.	Philipp.J.Sci., vol.74, p.45.	Divisoria market, Manila; San Pedro Bay, Basay, Samar; Carigara, Leyte; Antique Prov., Panay; Cebu, Cebu Prov., Barrio Sicaba, Cadiz Nuevo, Occidental Negros Province.
<u>Selaroides leptolepis</u>.	Bleeker, 1851.	Nat.Tijdschr.Ned.-Ind., vol.1, p.343.	Celebes.
	Bleeker*, 1851.	<u>Ibid</u>., vol.2, p.213, 475.	Celebes.
	Bleeker**, 1852.	<u>Ibid</u>., vol.3, p.741, 745.	--
	Herre*, 1934.	Fishes 1931 Philippine Exped., p.35.	Bauang Sur, La Union, Province; Manila, Luzon; Alabat Island; Capiz, Capiz Province, and Estancia, Iloilo Province, Panay.

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Herre, 1936-37.	Bull.Raffles Mus., No.13, p.22.	Manila Bay, Luzon; Estancia and Iloilo, Iloilo Province, Panay. Also Singapore and Johore Bahru, Johore, Malaya.
Herre, 1940-41.	Ibid., No.16, p.39.	Ibid.
Herre, 1953.	Res.Rep.U.S. Fish.Serv., No.20, p.282.	Philippines, East Indies, North to China and to Riukiu Islands, South to Australia, west to India and Arabia.
Munro, 1955.	Freshwater and Marine Fishes of Ceylon, p.125.	Coastal waters, Pearl Banks, and trawling grounds of Ceylon.
Munro, 1958.	Papua and New Guinea Agric. Jour., vol.10, No.4, p.180.	Port Moresby, New Guinea.

* Herre, A.W.C.T. 1953 Check list of Philippine fishes. Res.Rep.U.S.Fish.Serv., No.20, pp.282-83.

** Roxas, H.A. and Agco, A.G. 1941 A review of Philippine Carangidae. Philipp.J.Sci., vol.74, No.1, pp.1-82.

CHAPTER 4

FISHERY

Selaroides leptolepis forms a major fishery in the vicinity of Mandapam and occurs in fair abundance from February to March or April in the Gulf of Mannar and from April to May and August to October in the Palk Bay. The fish are consumed by all classes of people and being cheap are preferred especially by the poor. To have a general idea about the fishery of S. leptolepis and other carangids, fish landing centres from Devipatnam to Dhanushkodi on the Palk Bay and Dhanushkodi to Kilakarai on the Gulf of Mannar were visited. A description of the fishing methods, fishing season, the general trend of the fishery and means of disposal is given below.

Fishing methods.

Shore-seines and bag-nets are generally used to catch carangids and these are operated from Tuticorin type of boats and catamarans respectively.

BOATS

i) Tuticorin type of boat (Photograph 2). It is a comparatively large sized boat made of teak, measuring about 10 to 14 meters in length with the maximum width of nearly 2 meters and minimum depth of 0.9 meter, with nearly vertical stems and sterns. The sheerline is almost straight, and both ends of the boat are sharp. A peculiarity in the construction of the hulls is that the frames are not carried up to the gunwale, but cut away at the sheer plank. This uppermost plank, which is very broad is framed with a separate, short piece not fastened to the main frame, and mostly at some distance from it. The boat is generally rowed by 6 to 10 persons while paying out the net and the sail is not used. Mast and sail are used by the boat when moving from one fishing centre to another. The cost varies from Rs.1500 and above.

ii) Catamaran. The catamaran of this area is made up of three logs tied in such a way that the middle one is at a lower level than the other two at the sides. The catamarans work in pairs. One in each pair is slightly larger and wider than the other i.e. about 7 meters long by 0.9 meter wide as against about 6.4 meter by 0.8 meter. A light bamboo of considerable length (about 10 meters) which serves as a mast carries a triangular sail of cotton cloth. Mast and sail are common to each pair of catamaran. The two crafts are tied together at the anterior ends in a converging manner to minimise friction while sailing. Two men form the crew of each catamaran.

NETS AND THEIR MODE OF OPERATION

Shore-seines

i) 'Kara valai' (Tamil: 'kara' = shore, 'valai' = net)

(Plate 1, Fig. 3). Each 'kara valai' consists of a bag with side wings. The bag which measures nearly 10 meters is divided into belly and cod end. The cod end has the smallest mesh of 1.5 cm. The belly is preceded by the cotton wings, each measuring about 39 meters. The cotton wings are, in turn, followed by the hemp wings. At the junction of the two the mesh size is 23 cm. and as the hemp wings join the warps, the size of the mesh increases progressively. The hemp wing on either side measures about 480 meters and is bounded by a head rope and a foot rope to which are attached floats and sinkers respectively -- the floats at 2.8 meters apart and the sinkers at 9.14 meters. At the centre of the mouth of the bag, the head rope is provided with a master float and two smaller floats on either side. There are 12 to 15 warps, each measuring about 60 meters, attached to each hemp wing. Sometimes the number of warps is reduced to only four or five and in that case each warp measures about 160 meters. The net is operated from the Tuticorin type of boat.

The paying of the net starts with one end of the warp at the shore and as soon as a shoal is sighted, the whole net is payed out quickly around it and the other end is brought to the shore. On each side 10 to 20 men drag the net. As the net is pulled, the two parties come close together and by this time the bag of the net has come very near the shore (Photographs 2 to 4 show the various phases of operation of the net). At this stage precaution is taken to prevent the escape of fishes from the bag by closing its mouth tightly till the net is pulled on to the shore.

ii) 'Ola valai' (Tamil: 'ola' = palm leaf, 'valai' = net) (Photograph 5). It is a miniature type of shore-seine and resembles 'kara valai' in all the essential aspects except that the hemp wings are replaced by palm leaves attached to the ropes. There are ten warps on either side each measuring about 100 meters. The first five are provided with long palm leaves attached at regular intervals. As the leafy warps join the wing, they are supplemented with one to five warps of 1.25 cm. thickness.

The mode of operation is the same as in 'kara valai'.

Bag-net

'Madi valai' (Tamil: 'madi' = pocket or bag, 'valai' = net) (Plate 1, Fig. 4). Each 'madi valai' consists of a bag-like portion with side wings. The bag is about 9 meters long and 1.8 meters wide at the mouth. The cod end measures about 60 cm. and has a mesh of 0.5 cm. The bag is preceded by the hemp wings which measure 46 meters on either side and are in turn followed by the warps of the same length. At the junction of the hemp wing and the warp, a single float is attached to the head rope, and a sinker to the foot rope.

The net is shot from two catamarans which simultaneously move apart and proceed in the direction of the wind. After 15 to 30 minutes the two catamarans start coming close together and at the same time pulling the warps of the net. When the two catamarans lie side by side, the bag portion of the net has come to the surface (Plate 1, Fig.5). The almost total absence of free board in catamarans enables this net to be hauled with ease. The fishes are transferred from the cod end of the net to palmyra baskets. The operations are repeated till the baskets are full or it is time for their return to the shore.

Behaviour of the fish.

During April, May and June juveniles of S. leptolepis were observed moving under the umberalla of jelly fishes. Under the shield of jelly fishes, the juveniles perhaps move searching for food and at the same time are protected from their enemies. If the school is disturbed and any member happens to come in contact with the jelly fish, the tentacles of the latter soon operate and the fish are paralysed. Soemarto (1958) described the behaviour of Decapterus species from Indonesia and is of the opinion that fishes gather for protection than for food around a lure. Hornell

(1923) and Hardenberg (1949) observed gathering of various fishes such as Caranx leptolepis, C. mate, mackerel, Clupea species and Stromateus species around a lure and since these fishes are without protecting organs, it is possible that they collect around a lure or under umberalla of jelly fish for protection.

Fishing seasons.

The North-East monsoon starts in October-November and extends up to March-April. During this period the Palk Bay becomes rough and hence it is difficult to operate the nets. But during this season the fishing goes on in the Gulf of Mannar where the sea is relatively calm. Selaroides leptolepis and other carangids are most common in February and March.

In March-April the South-West monsoon starts and the Gulf of Mannar becomes rough. The operations are suspended on this side and all the boats move to the Palk Bay. The fishing lasts for 7 to 8 months on this side.

Fishing intensity during the off season in the Gulf of Mannar and the Palk Bay is very low.

General trend of fishery.

Selaroides leptolepis continues to occur throughout the year and forms a good fishery in the months of February to May and August to October, the peak period being February and September -- when ripe, spent, and spent-recovering individuals are met with. In April-May and October-November juveniles are common.

The fishery is constituted by the size groups ranging from 8 to 13 cm. and includes maturing, mature, spent and spent-recovering individuals. During April-May shoals of 5 to 8 cm. are also of common occurrence. From the data collected it has been noticed that the maximum size of the fish caught by the nets, operated in this locality is 15.3 cm. Such large individuals rarely occur in the commercial catches.

Besides S. leptolepis, Caranx melampygus was the most common carangid in January and March. Other carangids like Carangoides oblongus, C. armatus, Caranx sexfasciatus, Selar mate, S. malam and S. kalla also formed a small portion of the catch. Of rare occurrence were Alectis ciliaris and A. indica.

Table 1 gives the percentage of carangids in the total catch from May 1957 to April 1959 at Thangachimadam, Rameswaram and Rameswaram Road.

TABLE 1

PERCENTAGE OF CARANGIDS IN THE TOTAL CATCH FROM MAY 1957 TO APRIL 1959 AT THANGACHIMADAM, RAMESWARAM AND RAMESWARAM ROAD

Months and years	LOCALITIES (Figures are in kilograms)*								
	Thangachimadam			Rameswaram			Rameswaram Road		
	Total catch	Carangids**	% of carangids	Total catch	Carangids**	% of carangids	Total catch	Carangids**	% of carangids
i	ii	iii	iv	v	vi	vii	viii	ix	x
May 1957	50930	876 (876)	1.72	17948	805	4.49	--	--	--
June	96397	610 (610)	0.63	8456	460 (460)	5.44	--	--	--
July	168623	945	0.56	8231	233 (233)	2.83	--	--	--
August	270555	378 (378)	0.14	8185	450 (450)	5.50	--	--	--
September	195251	990 (990)	0.51	--	--	--	--	--	--
October	190059	1869 (1869)	0.98	4657	174	3.74	--	--	--
November 1957 to February 1958					No data				
March	--	--	--	--	--	--	5069	571 (571)	11.26
April	28996	663 (663)	2.29	--	--	--	2057	508 (494)	24.70

--Continued

i	ii	iii	iv	v	vi	vii	viii	ix	x
May 1958	169708	812 (349)	0.48	10602	193	1.82	--	--	--
June	--	--	--	21062	3300 (54)	15.67	--	--	--
July	--	--	--	--	--	--	--	--	--
August	270547	1448 (1448)	0.54	--	--	--	--	--	--
September	281972	1919 (1919)	0.68	--	--	--	--	--	--
October	170089	1901 (1429)	1.12	--	--	--	--	--	--
November	23013	56	0.24	--	--	--	--	--	--
December	--	--	--	--	--	--	--	--	--
January 1959	--	--	--	--	--	--	25314	1248 (32)	4.93
February	--	--	--	--	--	--	94727	3293 (197)	3.48
March	--	--	--	--	--	--	6581	825 (88)	12.54
April	--	--	--	--	--	--	21260	106	0.50

* Data obtained through the courtesy of the Survey Section of the Central Marine Fisheries Research Station, Mandapam Camp.

** Figures in brackets are for S. leptolepis.

The higher percentage of carangids at Thangachimadam in May and October 1957 and in April and October 1958 may be said to be due to the recruitment of juveniles of S. leptolepis to the fishery. At Thangachimadam, of the various carangids occurring, S. leptolepis is undoubtedly the most common.

Table 2 gives the percentage of carangids in the total landings for the years 1950 to 1958 from all over India.

TABLE 2

PERCENTAGE OF CARANGIDS IN THE TOTAL LANDINGS FOR THE YEARS 1950 TO 1958 FROM ALL OVER INDIA

Year		Percentage of carangids in the total catch
1950	..	1.06
1951	..	1.84
1952	..	1.83
1953	..	1.24
1954	..	2.79
1955	..	3.08
1956	..	7.88
1957	..	1.23
1958	..	2.40

From the above table it may be seen that carangid fishery in India was maximum during the year 1956.

Disposal of catch.

Selaroides leptolepis are generally consumed fresh and whenever the quantities landed are high, they are sun dried. The method of drying is very simple and does not involve much labour as the fish are small. They are never gutted.

The crude salt crystals are sprinkled on them and they are left to dry in the sun. The fish, when dried, are either sent to the interior or to other coastal areas or consumed by the local people themselves. Big carangids are sent to the interior in the fresh or cured state. The surplus cured fish are exported to Ceylon.

SECTION II

CHAPTER 5

POPULATION STUDIES

In order to have a rational basis for management and exploitation of the fishery resources and as an important step in understanding the biology of the species, we must have a good knowledge of the identity of the stocks supporting the fishery. When a species is commercially exploited, it becomes important to know whether the catch comes from a single population or from several populations which may or may not remain as discrete entities. The term population in this investigation is used to denote a group of individuals which inhabit a particular area in a given time showing certain distinct meristic or morphometric characters. If the species exploited belongs to one population, the fishing intensity at any one place is likely to have its effect in due course at other centres too and hence the imperative need to know about the nature and composition of the commercially exploited stocks.

Hubbs and Perlmutter (1942) followed the graphical method for the presentation of the morphometric and meristic data in _Anchoviella mitchilli_, as described by Dice and Leraas (1936), and observed that this method is less time consuming and facilitates an easy interpretation of the results. Different workers have taken different characters for this study viz., Hubbs and Perlmutter (_op. cit._) and

Clark (1947) used the vertebral counts as basis for separating the populations of <u>Anchoviella</u> <u>mitchilli</u>, and the Pacific Sardine along the North American Coast respectively. Roedel (1952) and Schaefer (1952) used both morphometric and meristic characters to separate the races of Pacific mackerel, <u>Pneumatophores</u> <u>diego</u> in California waters, and for the comparison of yellow fin tuna of Hawaiian waters and of the American West Coast respectively.

Ahlstrom (1957) reviewed the results of the studies on the subpopulations of Pacific fishes. He has indicated that there are two common approaches to the problem of recognizing subpopulations. One is an indirect approach and employs average morphometric and meristic differences between groups of fish to determine their probable separateness. The other is a direct approach and consists of tagging the species and their ultimate recovery. The first method is inexpensive and is widely used by fishery workers all over the world as compared to the second one which involves heavy expenditure.

The hypothesis underlying morphometric and meristic studies of subpopulations of fish as stated by Ahlstrom (<u>op</u>. <u>cit</u>.) is as follows:

"Under conditions of partial or complete isolation of groups of fish, slight differences in body proportions or meristic characters will be preserved in each group. The small differences will not necessarily be apparent in individual specimens but often only in an average of a large number of specimens. The significance of the differences is appraised by means of statistical procedures based on the theory of probability. The differences might be due to either environmental or heredity factors. It is usually extremely difficult to determine whether differences are phenotypic or genotypic; yet knowledge of the cause(s) of the differences is essential to an understanding of their significance."

Farris (1957) reviewed the literature on the use of chromatography as a tool for the study of speciation and holds the view that closely related members of a genus can be distinguished on the basis of their chromatographic patterns but points out that before the results of this technique can be used as _prima facie_ evidence for speciation, the limits of individual variation will have to be determined.

Marr (1957) has emphasized the need for a common terminology to distinguish population, subpopulation, stock and group and for each he has advanced a definition. He has avoided the use of the term "race" although these studies have been usually referred to as "racial" studies.

Julio (1958) used morphometric and meristic characters to segregate the different populations of _Cetengraulis mysticetus_ (Günther) from the various localities of Eastern

Tropical Pacific Ocean, and Broadhead (1959) made use of only morphometric characters in the case of *Neothunnus macropterus* from the Eastern Tropical Pacific Ocean.

Pillay (1951) used the morphometric characters in *Barbus*, and both morphometric and meristic characters in Hilsa in 1957. Sarojini (1953, 1957) made use of morpho-metric and meristic studies to show that *Mugil dussumieri* is a synonym of *M. parsia*. Prasad (1958b) separated the different races of *Clevelandia ios* in the California waters basing his results mainly on the meristic studies and suppor-ting them by the use of a single morphometric character.

It is a well known fact that ratios between various body parts may differ at different stages of life history in fishes and this has been demonstrated by Godsil (1948), Schaefer (1948), Schaefer and Walford (1950) and Marr (1955). Thus, these ratios cannot be used for comparing samples from different places. In order to overcome this difficulty, the comparison of different samples is based on the comparison of the regression of one dimension on that of another, taken as measurement of over-all size. Godsil (*op. cit.*), Schaefer (*op. cit.*), De Sylva *et al* (1956), Pillay (1957), Julio (1958), Prasad (1958b) etc., followed the method of regres-sions for the analysis of different characters to separate the populations, races or stocks as labelled by them.

In the present investigations the fork length was taken as an independent character and other lengths as dependent ones. For the meristic counts last dorsal and anal rays were counted as one each. All the measurements and counts were made by the author himself.

An attempt was made to ascertain whether the relation between the fork length and total length is linear. For this purpose 150 specimens ranging from 47 to 152 mm. in length were measured. The total length was taken from the tip of the lower jaw to the longest ray in the caudal fin when the two lobes were brought together. The fork length was plotted against the total length as a scatter diagram (Plate 1, Fig.6) and the relationship was found to be linear. The regression equation was then calculated by the formula $Y = a+bX$, where 'Y' and 'X' denote fork and total lengths respectively and 'a' and 'b' are two constants. The statistics are given below:

TABLE 3

STATISTICS OF FORK LENGTH AND TOTAL LENGTH OF S. LEPTOLEPIS

N	SX	SY	SXY	SX^2	SY^2
150	1812.0	1577.5	19984.89	22959.22	17396.89

--Continued

x^2	y^2	xy	b	$\bar{X}$	$\bar{Y}$
1070.26	806.85	928.69	0.8677	12.0800	10.5167

N = number of fish
SX, SY = sum of X and Y
SXY, SX^2, SY^2 = sum of products and squares
xy, x^2, y^2 = corrected sum of products and squares
b = regression coefficient
$\bar{X}$, $\bar{Y}$ = mean of X and Y

The regression equation from table 3 was found out to be $Y = 0.0349 + 0.8677X$. From Plate 1, Fig.6 it may be noticed that all the observed values lie very close to the regression line. From the same data the correlation coefficient 'r' was also calculated and found to be 0.9993 indicating a high correlation between the two lengths.

The significance of each morphometric and meristic character was considered at 5% probability level. In the columns 5% F., the values of the nearest or the next numbers, as described in F. tables, are given. Except for males and females individual points are not plotted, but the regression lines drawn in each case are fitted to the original data.

The following morphometric and meristic characters were selected (Plate 1, Fig.7):

a. Morphometric characters

- i. Head length
- ii. Snout to first dorsal
- iii. Snout to second dorsal
- iv. Snout to ventral
- v. Snout to anal
- vi. Maximum depth of body

b. Meristic characters

Number of rays of: i. Second dorsal, and
ii. Anal
iii. Number of vertebrae

To determine the differences, if any, between the males and females for the various characters studied, a sample of

50 fish was selected. These fish were then separated according to the sex, and measurements and counts for individual fish were recorded. Scatter diagrams for the morphometric characters revealed that there is a linear relationship of all the measurements on the fork length. The regression equations, therefore, were calculated as before. In this study 'X' denotes the fork length and 'Y' the various morphometric lengths. The methods of Analysis of Covariance and Analysis of Variance were employed for the morphometric and meristic characters respectively.

The number of vertebrae being 24 in all the specimens examined, this character was not analysed.

The statistical analyses for male and female characters are given in tables 4 to 8 and the final results are summarised in table 9.

TABLE 4

FEMALE AND MALE DATA OF MORPHOMETRIC MEASUREMENTS*

Sex	N	Independent variable X	Dependent variable Y	SX	SY	SX^2	SY^2	SXY
F	23	Fork length	Head length	2770.0	729.5	334590.00	23207.47	88103.60
M	27	Do	Do	3379.0	876.7	424679.00	28556.85	110094.00
F	23	Do	Snout to first dorsal	2770.0	945.6	334590.00	39029.52	114256.40
M	27	Do	Do	3379.0	1142.4	424679.00	48525.38	143533.60
F	23	Do	Snout to second dorsal	2770.0	1370.7	334590.00	81994.29	165619.80
M	27	Do	Do	3379.0	1661.6	424679.00	102717.10	208827.50
F	23	Do	Snout to ventral	2770.0	860.9	334590.00	32312.99	103969.10
M	27	Do	Do	3379.0	1043.6	424679.00	40472.80	131070.30
F	23	Do	Snout to anal	2770.0	1236.9	334590.00	66730.55	149400.70
M	27	Do	Do	3379.0	1501.0	424679.00	83790.62	188583.80
F	23	Do	Maximum depth of body	2770.0	834.6	334590.00	30352.36	100724.10
M	27	Do	Do	3379.0	1006.4	424679.00	37652.88	126414.20

* **Notations are** N = number of fish SX, SY = sum of X and Y

SX^2, SY^2, SXY = sum of squares and products

TABLE 5

REGRESSION DATA FOR MORPHOMETRIC MEASUREMENTS FOR FEMALE AND MALE

Sex	Independent variable X	Dependent variable Y	D.F.	Sum of squares and products			b	Errors of Estimate	
				x^2	y^2	xy		S.S.	D.F.
F	Fork length	Head length	22	985.66	69.63	246.43	0.2500	8.0188	21
M	Do	Do	26	1803.41	90.08	376.62	0.2088	11.4276	25
F	Do	Snout to first dorsal	22	985.66	153.03	373.27	0.3787	11.6725	21
M	Do	Do	26	1803.41	189.17	564.36	0.3129	12.5590	25
F	Do	Snout to second dorsal	22	985.66	306.53	539.85	0.5477	10.8520	21
M	Do	Do	26	1803.41	461.01	881.34	0.4887	30.2926	25
F	Do	Snout to ventral	22	985.66	89.13	286.80	0.2910	5.6791	21
M	Do	Do	26	1803.41	135.73	465.70	0.2582	15.4709	25
F	Do	Snout to anal	22	985.66	212.22	434.92	0.4412	20.3127	21
M	Do	Do	26	1803.41	346.14	736.43	0.4083	45.4158	25
F	Do	Maximum depth of body	22	985.66	67.27	209.24	0.2123	22.8517	21
M	Do	Do	26	1803.41	140.26	465.11	0.2579	20.3055	25

D.F. = Degrees of freedom
S.S. = Sum of squares
b = Regression coefficient

TABLE 6

COMPARISON OF FEMALE AND MALE DATA BY COVARIANCE ANALYSIS

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
HEAD LENGTH:					
Deviation from individual regressions within sexes	46	19.4464	0.4227	2.5564	4.05
Differences between regressions	1	1.0806	1.0806		
Deviation from total regression	47	20.5270			
SNOUT TO FIRST DORSAL:					
Deviation from individual regressions within sexes	46	24.2315	0.5267	5.2323	4.05
Differences between regressions	1	2.7559	2.7559		
Deviation from total regression	47	26.9874			
SNOUT TO SECOND DORSAL:					
Deviation from individual regressions within sexes	46	41.1446	0.8944	2.4801	4.05
Differences between regressions	1	2.2182	2.2182		
Deviation from total regression	47	43.3628			

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
SNOUT TO VENTRAL:					
Deviation from individual regressions within sexes	46	21.1500	0.4597		
				1.4859	4.05
Differences between regressions	1	0.6831	0.6831		
Deviation from total regression	47	21.8331			
SNOUT TO ANAL:					
Deviation from individual regressions within sexes	46	65.7285	1.4288		
				2.0722	252
Differences between regressions	1	0.6895	0.6895		
Deviation from total regression	47	66.4180			
MAXIMUM DEPTH OF BODY:					
Deviation from individual regressions within sexes	46	43.1572	0.9382		
				1.4137	4.05
Differences between regressions	1	1.3264	1.3264		
Deviation from total regression	47	44.4836			

TABLE 7

FREQUENCY DISTRIBUTION OF DORSAL AND ANAL FIN RAY COUNTS IN FEMALES AND MALES

Sex	N	Number of fish having dorsal fin ray counts of:			
		24	25		26
F	23	10	12		1
M	27	12	14		1
		Number of fish having anal fin ray counts of:			
		20	21	22	23
F	23	5	12	6	--
M	27	10	14	2	1

TABLE 8

ANALYSIS OF VARIANCE FOR DORSAL AND ANAL FIN RAYS OF FEMALES AND MALES

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
DORSAL FIN RAYS:					
Between sexes	1	0.0031	0.0031	107.5161	252
Within sexes	48	15.9969	0.3333		
Total	49	16.0000			
ANAL FIN RAYS:					
Between sexes	1	0.8767	0.8767	1.6423	4.04
Within sexes	48	25.6233	0.5338		
Total	49	26.5000			

TABLE 9

SIGNIFICANCE AND NON-SIGNIFICANCE OF VARIOUS CHARACTERS BETWEEN SEXES

Sex	Head length	Snout to first dorsal	Snout to second dorsal	Snout to ventral	Snout to anal
F v. M	NS	S	NS	NS	NS

--Continued

Sex	Maximum depth of body	Dorsal ray counts	Anal ray counts
F v. M	NS	NS	NS

NS = Non-significant S = Significant

It can be seen from Table 9 that except for snout to first dorsal, which is significant at 5% probability level, all the other characters are non-significant. Therefore, in the subsequent analyses of samples two sexes were treated together. The regression lines for each male and female character are plotted in Plate 1, Figs. 8 to 13.

Morphometric characters.

To test the homogeneity or otherwise of populations at a particular centre from year to year, and from different centres within a year samples were collected during 1957, 1958 and 1959 from Rameswaram, Thangachimadam, Rameswaram Road and Pudumadam. However, samples were not available at Rameswaram Road during 1957. In 1958 fish were also procured from Madras and Vizhingam.

Samples collected during different years from the same place and from different centres within a year were pooled together and analysed. In the event of their showing significant differences, they were then treated in combinations of two's. The relevant details of the analyses are given in tables 10 to 22 and the final results are presented in tables 23 and 24.

TABLE 10

STATISTICS OF MORPHOMETRIC MEASUREMENTS OF *S. LEPTOLEPIS* DURING 1957 FROM RAMESWARAM, THANGACHIMADAM AND PUDUMADAM*

Locality	N	SX	SY	SX^2	SY^2	SXY
1. HEAD LENGTH:						
Rameswaram	55	4033.5	1121.2	310500.99	23679.28	85669.10
Thangachimadam	66	6657.5	1806.0	677227.75	49887.00	183736.20
Pudumadam	41	3610.0	979.7	330310.50	24240.43	89437.90
2. SNOUT TO FIRST DORSAL:						
Rameswaram	55	4033.5	1388.3	310500.99	36637.75	106596.45
Thangachimadam	66	6657.5	2317.5	677227.75	82223.73	235867.65
Pudumadam	41	3610.0	1240.0	330310.50	38869.60	113256.25
3. SNOUT TO SECOND DORSAL:						
Rameswaram	55	4033.5	1954.1	310500.99	74287.31	150685.00
Thangachimadam	66	6657.5	3293.3	677227.75	165971.01	335176.55
Pudumadam	41	3610.0	1764.2	330310.50	78969.68	161440.40
4. SNOUT TO VENTRAL:						
Rameswaram	55	4033.5	1267.0	310500.99	30648.56	97496.78
Thangachimadam	66	6657.5	2098.9	677227.75	67399.19	213576.05
Pudumadam	41	3610.0	1149.2	330310.50	33392.98	104977.55
5. SNOUT TO ANAL:						
Rameswaram	55	4033.5	1774.2	310500.99	60337.10	136818.49
Thangachimadam	66	6657.5	2943.3	677227.75	132586.73	299576.35
Pudumadam	41	3610.0	1595.7	330310.50	64744.75	146187.10

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Locality	N	SX	SY	SX^2	SY^2	SXY
6. MAXIMUM DEPTH OF BODY:						
Rameswaram	55	4033.5	1185.9	310500.99	26816.99	91195.61
Thangachimadam	66	6657.5	1965.0	677227.75	59207.82	200108.80
Pudumadam	41	3610.0	1109.2	330310.50	31496.32	101724.25

* Notations are same as in table 4.

TABLE 11

REGRESSION AND CORRELATION DATA FOR MORPHOMETRIC MEASUREMENTS OF *S. LEPTOLEPIS* DURING 1957 FROM RAMESWARAM, THANGACHIMADAM AND PUDUMADAM

Locality	D.F.	Sum of squares and products			b	r	Errors of Estimate	
		x^2	y^2	xy			S.S.	D.F.
1. HEAD LENGTH:								
Rameswaram	54	14698.7673	823.1084	3444.3691	0.2343	0.9902	15.9878	53
Thangachi-madam	65	5677.6554	468.2728	1562.7910	0.2752	0.9584	38.1101	64
Pudumadam	40	12454.4025	830.3791	3176.5098	0.2550	0.9877	20.2066	39
2. SNOUT TO FIRST DORSAL:								
Rameswaram	54	14698.7673	1594.5339	4783.5764	0.3254	0.9880	37.3637	53
Thangachima-dam	65	5677.6554	847.8778	2098.6160	0.3696	0.9564	72.1722	64
Pudumadam	40	12454.4025	1367.1610	4075.7622	0.3272	0.9877	33.3486	39

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Locality	D.F.	Sum of squares and products			b	r	Errors of Estimate	
		x^2	y^2	xy			S.S.	D.F.
3. SNOUT TO SECOND DORSAL:								
Rameswaram	54	14698.7673	4859.9135	7378.4119	0.5019	0.8729	1156.1361	53
Thangachi-madam	65	5677.6554	1640.3299	2977.3872	0.5244	0.9756	78.9751	64
Pudumadam	40	12454.4025	3057.4449	6104.7415	0.4901	0.9894	65.1000	39
4. SNOUT TO VENTRAL:								
Rameswaram	54	14698.7673	1461.4873	4579.6073	0.3115	0.9880	34.6464	53
Thangachi-madam	65	5677.6554	650.9899	1857.4629	0.3271	0.9661	43.3135	64
Pudumadam	40	12454.4025	1181.7449	3791.8915	0.3044	0.9884	27.2583	39
5. SNOUT TO ANAL:								
Rameswaram	54	14698.7673	3104.6339	6705.1137	0.4561	0.9926	45.9727	53
Thangachi-madam	65	5677.6554	1328.9287	2682.1114	0.4723	0.9764	61.9055	64
Pudumadam	40	12454.4025	2640.8844	5687.6610	0.4566	0.9918	43.4505	39
6. MAXIMUM DEPTH OF BODY:								
Rameswaram	54	14698.7673	1246.8299	4226.0164	0.2875	0.9871	31.8155	53
Thangachi-madam	65	5677.6554	704.4110	1896.8682	0.3340	0.9480	70.6796	64
Pudumadam	40	12454.4025	1488.4020	4060.5427	0.3260	0.9438	164.5323	39

r = Correlation coefficient
S.S. = Sum of squares
D.F. = Degrees of freedom
b = Regression coefficient

TABLE 12

STATISTICS OF MORPHOMETRIC MEASUREMENTS OF S. LEPTOLEPIS DURING 1958 FROM RAMESWARAM, THANGACHIMADAM, RAMESWARAM ROAD, PUDUMADAM, MADRAS AND VIZHINGAM*

Locality	N	SX	SY	SX^2	SY^2	SXY
1. HEAD LENGTH:						
Rameswaram	44	3653.0	987.2	323127.00	23275.50	86668.10
Thangachimadam	50	4733.7	1278.8	469219.19	34112.82	126474.85
Rameswaram Road	50	5908.0	1563.4	704667.50	49291.98	186296.10
Pudumadam	52	5432.9	1424.0	579516.65	39718.24	151668.00
Madras	50	6149.0	1606.2	759269.00	51764.32	198197.60
Vizhingam	17	1453.0	377.5	124991.00	8421.27	32432.60
2. SNOUT TO FIRST DORSAL:						
Rameswaram	44	3653.0	1242.8	323127.00	37142.94	109520.70
Thangachimadam	50	4733.7	1637.8	469219.19	56063.24	162146.65
Rameswaram Road	50	5908.0	1993.8	704667.50	80380.44	237913.60
Pudumadam	52	5432.9	1822.4	579516.65	65176.54	194297.44
Madras	50	6149.0	2088.0	759269.00	87554.90	257790.00
Vizhingam	17	1453.0	475.4	124991.00	13364.38	40845.80
3. SNOUT TO SECOND DORSAL:						
Rameswaram	44	3653.0	1782.6	323127.00	77135.12	157854.70
Thangachimadam	50	4733.7	2346.0	469219.19	115630.76	232891.50
Rameswaram Road	50	5908.0	2906.9	704667.50	170780.49	346838.15
Pudumadam	52	5432.9	2632.8	579516.65	136198.26	280901.51
Madras	50	6149.0	3032.3	759269.00	184711.39	374447.30
Vizhingam	17	1453.0	678.6	124991.00	27293.72	58388.40

--<u>Continued</u>

Locality	N	SX	SY	SX^2	SY^2	SXY
4. SNOUT TO VENTRAL:						
Rameswaram	44	3653.0	1141.1	323127.00	31653.69	101112.00
Thangachimadam	50	4733.7	1506.9	469219.19	47542.85	149314.54
Rameswaram Road	50	5908.0	1850.2	704667.50	69118.32	220638.90
Pudumadam	52	5432.9	1684.8	579516.65	55610.04	179470.55
Madras	50	6149.0	1904.5	759269.00	72785.79	235039.40
Vizhingam	17	1453.0	437.3	124991.00	11324.97	37605.90
5. SNOUT TO ANAL:						
Rameswaram	44	3653.0	1629.5	323127.00	65205.53	145080.60
Thangachimadam	50	4733.7	2102.7	469219.19	92875.45	208684.40
Rameswaram Road	50	5908.0	2629.1	704667.50	139938.81	313895.15
Pudumadam	52	5432.9	2387.3	579516.65	112062.37	254793.88
Madras	50	6149.0	2737.9	759269.00	150521.17	337984.50
Vizhingam	17	1453.0	607.8	124991.00	21956.44	52343.00
6. MAXIMUM DEPTH OF BODY:						
Rameswaram	44	3653.0	1095.2	323127.00	29210.76	97095.20
Thangachimadam	50	4733.7	1425.6	469219.19	42588.44	141294.05
Rameswaram Road	50	5908.0	1790.2	704667.50	64622.12	213292.25
Pudumadam	52	5432.9	1636.2	579516.65	52455.00	174189.67
Madras	50	6149.0	1841.0	759269.00	68005.24	227138.30
Vizhingam	17	1453.0	450.4	124991.00	11987.66	38685.10

* Notations are same as in table 4.

TABLE 13

REGRESSION AND CORRELATION DATA FOR MORPHOMETRIC MEASUREMENTS OF *S. LEPTOLEPIS* DURING 1958 FROM RAMESWARAM, THANGACHIMADAM, RAMESWARAM ROAD, PUDUMADAM, MADRAS AND VIZHINGAM*

Locality	D.F.	Sum of squares and products			b	r	Errors of Estimate	
		x^2	y^2	xy			S.S.	D.F.
1. HEAD LENGTH:								
Rameswaram	43	19844.9773	1126.3219	4708.0637	0.2372	0.9958	9.3711	42
Thangachimadam	49	21060.8762	1406.2312	5405.7388	0.2566	0.9933	18.7291	48
Rameswaram Road	49	6578.2200	407.5888	1564.7560	0.2378	0.9956	35.3816	48
Pudumadam	51	11893.5268	722.5477	2890.1231	0.2430	0.9859	20.2488	50
Madras	49	3064.9800	166.7512	667.1240	0.2176	0.9332	21.5449	48
Vizhingam	16	802.2353	38.5495	167.4530	0.2087	0.9522	3.5966	15
2. SNOUT TO FIRST DORSAL:								
Rameswaram	43	19844.9773	2039.4891	6340.0546	0.3194	0.9966	13.9745	42
Thangachimadam	49	21060.8762	2415.4632	7089.5728	0.3366	0.9940	28.9508	48
Rameswaram Road	49	6578.2200	875.6712	2326.1920	0.3536	0.9692	53.0826	48
Pudumadam	51	11893.5268	1308.4293	3895.1908	0.3275	0.9874	32.7345	50
Madras	49	3064.9800	360.0200	1007.7600	0.3287	0.9593	28.6703	48
Vizhingam	16	802.2353	69.9589	213.0824	0.2656	0.8999	13.3620	15
3. SNOUT TO SECOND DORSAL:								
Rameswaram	43	19844.9773	4915.5119	9858.3865	0.4967	0.9982	18.1627	42
Thangachimadam	49	21060.8762	5556.4400	10786.2960	0.5121	0.9971	32.2548	48
Rameswaram Road	49	6578.2200	1779.1378	3358.8460	0.5106	0.9818	64.1076	48
Pudumadam	51	11893.5268	2897.5708	5829.6039	0.4901	0.9963	40.1945	50
Madras	49	3064.9800	814.5242	1535.0460	0.5008	0.9715	45.7211	48
Vizhingam	16	802.2353	205.6048	388.0589	0.4837	0.9555	17.8922	15

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Locality	D.F.	Sum of squares and products			b	r	Errors of Estimate	
		x^2	y^2	xy			S.S.	D.F.
4. SNOUT TO VENTRAL:								
Rameswaram	43	19844.9773	2060.2989	6374.7660	0.3212	0.9970	12.5445	42
Thangachimadam	49	21060.8762	2127.8978	6650.2894	0.3157	0.9934	27.9686	48
Rameswaram Road	49	6578.2200	653.5192	2019.2680	0.3069	0.9739	33.6793	48
Pudumadam	51	11893.5268	1022.5200	3444.5900	0.2896	0.9877	24.9017	50
Madras	49	3064.9800	243.3850	823.9900	0.2688	0.9540	21.8634	48
Vizhingam	16	802.2353	76.0706	229.6118	0.2862	0.9294	10.3523	15
5. SNOUT TO ANAL:								
Rameswaram	43	19844.9773	4858.4789	9795.0660	0.4935	0.9975	23.8391	42
Thangachimadam	49	21060.8762	4448.5042	9613.3802	0.4564	0.9932	60.4115	48
Rameswaram Road	49	6578.2200	1695.4738	3240.6940	0.4926	0.9704	98.9785	48
Pudumadam	51	11893.5268	2462.3452	5371.5306	0.4516	0.9926	36.3751	50
Madras	49	3064.9800	599.2418	1277.5580	0.4168	0.9427	66.7247	48
Vizhingam	16	802.2353	225.8024	393.9765	0.4910	0.9257	32.3212	15
6. MAXIMUM DEPTH OF BODY:								
Rameswaram	43	19844.9773	1950.2364	6168.7091	0.3108	0.9916	32.7250	42
Thangachimadam	49	21060.8762	1941.7328	6326.7976	0.3004	0.9894	41.1297	48
Rameswaram Road	49	6578.2200	525.7992	1762.2180	0.2678	0.9475	53.7244	48
Pudumadam	51	11893.5268	971.3377	3241.3820	0.2725	0.9536	87.9532	50
Madras	49	3064.9800	219.6200	732.1200	0.2388	0.9427	44.7414	48
Vizhingam	16	802.2353	54.7095	189.1471	0.2357	0.9029	10.1134	15

* Notations are same as in table 11.

TABLE 14

STATISTICS OF MORPHOMETRIC MEASUREMENTS OF S. LEPTOLEPIS DURING 1959 FROM RAMESWARAM, THANGACHIMADAM, RAMESWARAM ROAD AND PUDUMADAM*

Locality	N	SX	SY	SX^2	SY^2	SXY
1. HEAD LENGTH:						
Rameswaram	40	3467.0	909.2	304995.00	21028.18	80055.70
Thangachimadam	40	4018.0	1063.1	416342.00	29198.23	110230.70
Rameswaram Road	50	6202.0	1640.6	772542.00	54117.42	204399.10
Pudumadam	50	5724.0	1492.6	665146.00	45155.06	173233.50
2. SNOUT TO FIRST DORSAL:						
Rameswaram	40	3467.0	1175.7	304995.00	35095.89	103435.70
Thangachimadam	40	4018.0	1372.0	416342.00	48630.84	142273.00
Rameswaram Road	50	6202.0	2122.2	772542.00	90563.64	264461.70
Pudumadam	50	5724.0	1935.5	665146.00	76059.53	224836.20
3. SNOUT TO SECOND DORSAL:						
Rameswaram	40	3467.0	1689.9	304995.00	72686.33	148853.50
Thangachimadam	40	4018.0	1982.1	416342.00	101775.25	205806.70
Rameswaram Road	50	6202.0	3074.0	772542.00	189901.94	382986.90
Pudumadam	50	5724.0	2811.8	665146.00	160693.04	326822.30
4. SNOUT TO VENTRAL:						
Rameswaram	40	3467.0	1076.6	304995.00	29412.60	94697.10
Thangachimadam	40	4018.0	1253.6	416342.00	40574.56	129946.50
Rameswaram Road	50	6202.0	1957.8	772542.00	77019.02	243889.70
Pudumadam	50	5724.0	1798.2	665146.00	65594.60	208825.20
5. SNOUT TO ANAL:						
Rameswaram	40	3467.0	1528.0	304995.00	59348.90	134505.70
Thangachimadam	40	4018.0	1776.1	416342.00	81790.79	184446.90
Rameswaram Road	50	6202.0	2833.4	772542.00	161382.84	353023.50
Pudumadam	50	5724.0	2607.3	665146.00	137869.03	303216.40

--Continued

Locality	N	SX	SY	SX^2	SY^2	SXY
6. MAXIMUM DEPTH OF BODY:						
Rameswaram	40	3467.0	1020.9	304995.00	26377.53	89656.00
Thangachimadam	40	4018.0	1176.1	416342.00	35617.95	121723.10
Rameswaram Road	50	6202.0	1817.9	772542.00	66379.45	226386.60
Pudumadam	50	5724.0	1692.8	665146.00	58038.44	196357.30

* Notations are same as in table 4.

TABLE 15

REGRESSION AND CORRELATION DATA FOR MORPHOMETRIC MEASUREMENTS OF S. LEPTOLEPIS DURING 1959 FROM RAMESWARAM, THANGACHIMADAM, RAMESWARAM ROAD AND PUDUMADAM*

Locality	D.F.	Sum of squares and products			b	r	Errors of Estimate	
		x^2	y^2	xy			S.S.	D.F.
1. HEAD LENGTH:								
Rameswaram	39	4492.7750	362.0640	1250.7900	0.2784	0.9807	13.8437	38
Thangachimadam	39	12733.9000	943.6898	3442.3050	0.2703	0.9929	13.1451	38
Rameswaram Road	49	3245.9200	286.0528	898.9760	0.2769	0.9329	37.0763	48
Pudumadam	49	9862.4800	597.9648	2360.6520	0.2393	0.9725	32.9267	48
2. SNOUT TO FIRST DORSAL:								
Rameswaram	39	4492.7750	539.1278	1531.9025	0.3409	0.9843	16.7947	38
Thangachimadam	39	12733.9000	1571.2400	4455.6000	0.3499	0.9960	12.2227	38
Rameswaram Road	49	3245.9200	488.9832	1224.0120	0.3770	0.9715	27.4175	48
Pudumadam	49	9862.4800	1136.3250	3260.1600	0.3305	0.9739	58.6404	48

--Continued

Locality	D.F.	Sum of squares and products			b	r	Errors of Estimate	
		x^2	y^2	xy			S.S.	D.F.
3. SNOUT TO SECOND DORSAL:								
Rameswaram	39	4492.7750	1292.2798	2381.4175	0.5300	0.9881	29.9978	38
Thangachimadam	39	12733.9000	3557.2398	6704.7550	0.5265	0.9962	26.9986	38
Rameswaram Road	49	3245.9200	912.4200	1687.9400	0.5200	0.9808	34.6592	48
Pudumadam	49	9862.4800	2568.6552	4927.4360	0.4996	0.9790	106.8378	48
4. SNOUT TO VENTRAL:								
Rameswaram	39	4492.7750	435.9110	1382.7950	0.3077	0.9881	10.3117	38
Thangachimadam	39	12733.9000	1286.7360	4022.3800	0.3158	0.9936	16.1480	38
Rameswaram Road	49	3245.9200	359.4032	1044.1880	0.3216	0.9667	23.4958	48
Pudumadam	49	9862.4800	924.1352	2967.2640	0.3008	0.9829	31.3927	48
5. SNOUT TO ANAL:								
Rameswaram	39	4492.7750	979.3000	2066.3000	0.4599	0.9851	28.9752	38
Thangachimadam	39	12733.9000	2927.5098	6037.6550	0.4741	0.9888	64.8144	38
Rameswaram Road	49	3245.9200	819.7288	1568.5640	0.4832	0.9616	61.7333	48
Pudumadam	49	9862.4800	2367.7642	4732.6960	0.4798	0.9793	96.6913	48
6. MAXIMUM DEPTH OF BODY:								
Rameswaram	39	4492.7750	321.6098	1169.4925	0.2603	0.9729	17.1849	38
Thangachimadam	39	12733.9000	1037.6698	3583.8550	0.2814	0.9859	29.0223	38
Rameswaram Road	49	3245.9200	284.2418	894.2840	0.2755	0.9317	37.8575	48
Pudumadam	49	9862.4800	727.0032	2565.5560	0.2601	0.9581	59.6176	48

* Notations are same as in table 11.

TABLE 16

COMPARISON OF DIFFERENT BODY LENGTHS WITHIN YEARS (1957, 1958 AND 1959) BY COVARIANCE ANALYSIS FROM RAMESWARAM

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
HEAD LENGTH:					
Deviation from individual regressions within years	133	39.2026	0.2947	12.2460	3.06
Differences among regressions	2	7.2179	3.6089		
Deviation from total regression	135	46.4205			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within years (1957 & 1958)	95	25.3589	0.2669	3.7276	253
Differences between regressions	1	0.0716	0.0716		
Deviation from total regression	96	25.4305			
Deviation from individual regressions within years (1957 & 1959)	91	29.8315	0.3278	20.3871	3.94
Differences between regressions	1	6.6829	6.6829		
Deviation from total regression	92	36.5144			

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within years (1958 & 1959)	80	23.2148	0.2901	21.3912	3.96
Differences between regressions	1	6.2056	6.2056		
Deviation from total regression	81	29.4204			
SNOUT TO FIRST DORSAL:					
Deviation from individual regressions within years	133	68.1329	0.5122	2.0777	3.06
Differences among regressions	2	2.1284	1.0642		
Deviation from total regression	135	70.2613			
SNOUT TO SECOND DORSAL:					
Deviation from individual regressions within years	133	1204.2966	9.0548	4.4532	19.49
Differences among regressions	2	4.0667	2.0333		
Deviation from total regression	135	1208.3633			

--<u>Continued</u>

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
SNOUT TO VENTRAL:					
Deviation from individual regressions within years	133	57.5026	0.4323	1.3125	3.06
Differences among regressions	2	1.1349	0.5674		
Deviation from total regression	135	58.6375			
SNOUT TO ANAL:					
Deviation from individual regressions within years	133	98.7870	0.7427	8.7989	3.06
Differences among regressions	2	13.0700	6.5350		
Deviation from total regression	135	111.8570			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within years (1957 & 1958)	95	69.8118	0.7348	16.0831	3.94
Differences between regressions	1	11.8179	11.8179		
Deviation from total regression	96	81.6297			

--<u>Continued</u>

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within years (1957 & 1959)	91	74.9479	0.8236	17.0517	253
Differences between regressions	1	0.0483	0.0483		
Deviation from total regression	92	74.9962			
Deviation from individual regressions within years (1958 & 1959)	80	52.8143	0.6601	21.4381	3.96
Differences between regressions	1	14.1513	14.1513		
Deviation from total regression	81	66.9656			
MAXIMUM DEPTH OF BODY:					
Deviation from individual regressions within years	133	81.7254	0.6144	9.0779	3.06
Differences among regressions	2	11.1551	5.5775		
Deviation from total regression	135	92.8805			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within years (1957 & 1958)	95	64.5405	0.6793	6.7697	3.94
Differences between regressions	1	4.5987	4.5987		
Deviation from total regression	96	69.1392			
Deviation from individual regressions within years (1957 & 1959)	91	49.0004	0.5384	4.7293	3.94
Differences between regressions	1	2.5463	2.5463		
Deviation from total regression	92	51.5467			
Deviation from individual regressions within years (1958 & 1959)	80	49.9099	0.6238	15.0001	3.96
Differences between regressions	1	9.3571	9.3571		
Deviation from total regression	81	59.2670			

TABLE 17

COMPARISON OF DIFFERENT BODY LENGTHS WITHIN YEARS (1957, 1958 AND 1959) BY COVARIANCE ANALYSIS FROM THANGACHIMADAM

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
HEAD LENGTH:					
Deviation from individual regressions within years	150	69.9843	0.4665	2.5260	3.06
Differences among regressions	2	2.3569	1.1784		
Deviation from total regression	152	72.3412			
SNOUT TO FIRST DORSAL:					
Deviation from individual regressions within years	150	113.3457	0.7556	3.4478	3.06
Differences among regressions	2	5.2104	2.6052		
Deviation from total regression	152	118.5561			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within years (1957 & 1958)	112	101.1230	0.9028	5.3958	3.92
Differences between regressions	1	4.8714	4.8714		
Deviation from total regression	113	105.9944			

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within years (1957 & 1959)	102	84.3949	0.8274	13.9328	3.92
Differences between regressions	1	11.5280	11.5280		
Deviation from total regression	103	95.9229			
Deviation from individual regressions within years (1958 & 1959)	86	41.1735	0.4787	2.9224	3.94
Differences between regressions	1	1.3990	1.3990		
Deviation from total regression	87	42.5725			
SNOUT TO SECOND DORSAL:					
Deviation from individual regressions within years	150	138.2285	0.9215	1.0135	3.06
Differences among regressions	2	1.8680	0.9340		
Deviation from total regression	152	140.0965			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
SNOUT TO VENTRAL:					
Deviation from individual regressions within years	150	87.4301	0.5828	1.8584	19.49
Differences among regressions	2	0.6273	0.3136		
Deviation from total regression	152	88.0574			
SNOUT TO ANAL:					
Deviation from individual regressions within years	150	187.1314	1.2475	1.1622	3.06
Differences among regressions	2	2.8998	1.4499		
Deviation from total regression	152	190.0312			
MAXIMUM DEPTH OF BODY:					
Deviation from individual regressions within years	150	140.8316	0.9388	5.8365	3.06
Differences among regressions	2	10.9588	5.4794		
Deviation from total regression	152	151.7904			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within years (1957 & 1958)	112	111.8093	0.9982		
Differences between regressions	1	5.0753	5.0753	5.0844	3.92
Deviation from total regression	113	116.8846			
Deviation from individual regressions within years (1957 & 1959)	102	99.7019	0.9774		
Differences between regressions	1	10.8858	10.8858	11.1375	3.92
Deviation from total regression	103	110.5877			
Deviation from individual regressions within years (1958 & 1959)	86	70.1520	0.8157		
Differences between regressions	1	2.8507	2.8507	3.4947	3.94
Deviation from total regression	87	73.0027			

TABLE 18

COMPARISON OF DIFFERENT BODY LENGTHS WITHIN YEARS (1958 AND 1959) BY COVARIANCE ANALYSIS FROM RAMESWARAM ROAD

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
HEAD LENGTH:					
Deviation from individual regressions within years	96	72.4579	0.7547	4.3997	3.94
Differences between regressions	1	3.3205	3.3205		
Deviation from total regression	97	75.7784			
SNOUT TO FIRST DORSAL:					
Deviation from individual regressions within years	96	80.5001	0.8385	1.4280	3.94
Differences between regressions	1	1.1974	1.1974		
Deviation from total regression	97	81.6975			
SNOUT TO SECOND DORSAL:					
Deviation from individual regressions within years	96	98.7668	1.0288	5.3388	253
Differences between regressions	1	0.1927	0.1927		
Deviation from total regression	97	98.9595			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
SNOUT TO VENTRAL:					
Deviation from individual regressions within years	96	57.1751	0.5955	1.2627	253
Differences between regressions	1	0.4716	0.4716		
Deviation from total regression	97	57.6467			
SNOUT TO ANAL:					
Deviation from individual regressions within years	96	160.7118	1.6740	8.7232	253
Differences between regressions	1	0.1919	0.1919		
Deviation from total regression	97	160.9037			
MAXIMUM DEPTH OF BODY:					
Deviation from individual regressions within years	96	91.5819	0.9539	7.5526	253
Differences between regressions	1	0.1263	0.1263		
Deviation from total regression	97	91.7082			

TABLE 19

COMPARISON OF DIFFERENT BODY LENGTHS WITHIN YEARS (1957, 1958 AND 1959) BY COVARIANCE ANALYSIS FROM PUDUMADAM

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
HEAD LENGTH:					
Deviation from individual regressions within years	137	73.3821	0.5356	1.4550	3.06
Differences among regressions	2	1.5586	0.7793		
Deviation from total regression	139	74.9407			
SNOUT TO FIRST DORSAL:					
Deviation from individual regressions within years	137	124.7235	0.9103	25.4985	19.49
Differences among regressions	2	0.0714	0.0357		
Deviation from total regression	139	124.7949			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within years (1957 & 1958)	89	66.0831	0.7425	3712.5	253
Differences between regressions	1	0.0002	0.0002		
Deviation from total regression	90	66.0833			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within years (1957 & 1959)	87	91.9890	1.0573	17.5923	253
Differences between regressions	1	0.0601	0.0601		
Deviation from total regression	88	92.0491			
Deviation from individual regressions within years (1958 & 1959)	98	91.3749	0.9323	18.5347	253
Differences between regressions	1	0.0503	0.0503		
Deviation from total regression	99	91.4252			
SNOUT TO SECOND DORSAL:					
Deviation from individual regressions within years	137	212.1323	1.5484	4.9359	19.49
Differences among regressions	2	0.6275	0.3137		
Deviation from total regression	139	212.7598			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
SNOUT TO VENTRAL:					
Deviation from individual regressions within years	137	83.5527	0.6098	1.1756	3.06
Differences among regressions	2	1.4339	0.7169		
Deviation from total regression	139	84.9866			
SNOUT TO ANAL:					
Deviation from individual regressions within years	137	176.5169	1.2884	1.8527	3.06
Differences among regressions	2	4.7742	2.3871		
Deviation from total regression	139	181.2911			
MAXIMUM DEPTH OF BODY:					
Deviation from individual regressions within years	137	312.1031	2.2781	6.2579	3.06
Differences among regressions	2	28.5127	14.2563		
Deviation from total regression	139	340.6158			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

TABLE 20

COMPARISON OF DIFFERENT BODY LENGTHS OF S. LEPTOLEPIS BY COVARIANCE ANALYSIS FROM RAMESWARAM, THANGACHIMADAM AND PUDUMADAM DURING 1957

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
HEAD LENGTH:					
Deviation from individual regressions within places	156	74.3045	0.4763	7.9044	3.04
Differences among regressions	2	7.5299	3.7649		
Deviation from total regression	158	81.8344			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Thangachimadam)	117	54.0979	0.4623	14.8360	3.92
Differences between regressions	1	6.8587	6.8587		
Deviation from total regression	118	60.9566			
Deviation from individual regressions within places (Rameswaram & Pudumadam)	92	36.1944	0.3934	7.3579	3.94
Differences between regressions	1	2.8946	2.8946		
Deviation from total regression	93	39.0890			

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Thangachimadam & Pudumadam)	103	58.3167	0.5661	2.8115	3.92
Differences between regressions	1	1.5916	1.5916		
Deviation from total regression	104	59.9083			
SNOUT TO FIRST DORSAL:					
Deviation from individual regressions within places	156	142.8845	0.9159	5.0488	3.04
Differences among regressions	2	9.2484	4.6242		
Deviation from total regression	158	152.1329			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Thangachimadam)	117	109.5359	0.9362	8.9688	3.92
Differences between regressions	1	8.3966	8.3966		
Deviation from total regression	118	117.9325			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Pudumadam)	92	70.7123	0.7686	1.8208	253
Differences between regressions	1	0.4221	0.4221		
Deviation from total regression	93	71.1344			
Deviation from individual regressions within places (Thangachimadam & Pudumadam)	103	105.5208	1.0244	6.8350	3.92
Differences between regressions	1	7.0018	7.0018		
Deviation from total regression	104	112.5226			
SNOUT TO SECOND DORSAL:					
Deviation from individual regressions within places	156	1300.2112	8.3346	3.6389	19.49
Differences among regressions	2	4.5808	2.2904		
Deviation from total regression	158	1304.7920			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
SNOUT TO VENTRAL:					
Deviation from individual regressions within places	156	105.2182	0.6744	1.4897	3.04
Differences among regressions	2	2.0095	1.0047		
Deviation from total regression	158	107.2277			
SNOUT TO ANAL:					
Deviation from individual regressions within places	156	151.3287	0.9700	1.6126	19.49
Differences among regressions	2	1.2031	0.6015		
Deviation from total regression	158	152.5318			
MAXIMUM DEPTH OF BODY:					
Deviation from individual regressions within places	156	267.0274	1.7117	4.0695	3.04
Differences among regressions	2	13.9319	6.9659		
Deviation from total regression	158	280.9593			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Thangachimadam)	117	102.4951	0.8760	10.1464	3.92
Differences between regressions	1	8.8883	8.8883		
Deviation from total regression	118	111.3834			
Deviation from individual regressions within places (Rameswaram & Pudumadam)	92	196.3478	2.1342	4.6883	3.94
Differences between regressions	1	10.0059	10.0059		
Deviation from total regression	93	206.3537			
Deviation from individual regressions within places (Thangachimadam & Pudumadam)	103	235.2119	2.2836	9.0153	254
Differences between regressions	1	0.2533	0.2533		
Deviation from total regression	104	235.4652			

TABLE 21

COMPARISON OF DIFFERENT BODY LENGTHS OF S. LEPTOLEPIS BY COVARIANCE ANALYSIS FROM RAMESWARAM, THANGACHIMADAM, RAMESWARAM ROAD, PUDUMADAM, MADRAS AND VIZHINGAM DURING 1958

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
HEAD LENGTH:					
Deviation from individual regressions within places	251	108.8721	0.4337	3.5317	2.23
Differences among regressions	5	7.6586	1.5317		
Deviation from total regression	256	116.5307			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Thangachimadam)	90	28.1002	0.3122	12.3552	3.94
Differences between regressions	1	3.8573	3.8573		
Deviation from total regression	91	31.9575			
Deviation from individual regressions within places (Rameswaram & Rameswaram Road)	90	44.7527	0.4972	261.6842	253
Differences between regressions	1	0.0019	0.0019		
Deviation from total regression	91	44.7546			

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Pudumadam)	92	29.6199	0.3219	1.4827	253
Differences between regressions	1	0.2171	0.2171		
Deviation from total regression	93	29.8370			
Deviation from individual regressions within places (Rameswaram & Madras)	90	30.9160	0.3435	2.9639	3.94
Differences between regressions	1	1.0181	1.0181		
Deviation from total regression	91	31.9341			
Deviation from individual regressions within places (Rameswaram & Vizhingam)	57	12.9677	0.2275	2.7542	4.00
Differences between regressions	1	0.6266	0.6266		
Deviation from total regression	58	13.5943			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Thangachimadam & Rameswaram Road)	96	54.1107	0.5636	3.1442	3.94
Differences between regressions	1	1.7721	1.7721		
Deviation from total regression	97	55.8828			
Deviation from individual regressions within places (Thangachimadam & Pudumadam)	98	38.9779	0.3977	3.5725	3.94
Differences between regressions	1	1.4208	1.4208		
Deviation from total regression	99	40.3987			
Deviation from individual regressions within places (Thangachimadam & Madras)	96	40.2740	0.4195	9.7067	3.94
Differences between regressions	1	4.0720	4.0720		
Deviation from total regression	97	44.3460			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Thangachimadam & Vizhingam)	63	22.3257	0.3543	5.0124	3.99
Differences between regressions	1	1.7759	1.7759		
Deviation from total regression	64	24.1016			
Deviation from individual regressions within places (Rameswaram Road & Pudumadam)	98	55.6304	0.5676	5.0951	253
Differences between regressions	1	0.1114	0.1114		
Deviation from total regression	99	55.7418			
Deviation from individual regressions within places (Rameswaram Road & Madras)	96	56.9265	0.5929	1.4403	3.94
Differences between regressions	1	0.8540	0.8540		
Deviation from total regression	97	57.7805			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram Road & Vizhingam)	63	38.9782	0.6187	1.0194	253
Differences between regressions	1	0.6069	0.6069		
Deviation from total regression	64	39.5851			
Deviation from individual regressions within places (Pudumadam & Madras)	98	41.7937	0.4264	3.6695	3.94
Differences between regressions	1	1.5647	1.5647		
Deviation from total regression	99	43.3584			
Deviation from individual regressions within places (Pudumadam & Vizhingam)	65	23.8454	0.3668	2.4056	3.99
Differences between regressions	1	0.8824	0.8824		
Deviation from total regression	66	24.7278			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Madras and Vizhingam)	63	25.1415	0.3990	7.8853	253
Differences between regressions	1	0.0506	0.0506		
Deviation from total regression	64	25.1921			
SNOUT TO FIRST DORSAL:					
Deviation from individual regressions within places	251	170.7747	0.6803	2.9970	2.23
Differences among regressions	5	10.1947	2.0389		
Deviation from total regression	256	180.9694			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

Deviation from individual regressions within places (Rameswaram & Thangachimadam)	90	42.9253	0.4769	5.3429	3.94
Differences between regressions	1	2.7865	2.7865		
Deviation from total regression	91	45.7118			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Rameswaram Road)	90	67.0571	0.7450	7.7297	3.94
Differences between regressions	1	5.7587	5.7587		
Deviation from total regression	91	72.8158			
Deviation from individual regressions within places (Rameswaram & Pudumadam)	92	46.7090	0.5077	1.0599	253
Differences between regressions	1	0.4790	0.4790		
Deviation from total regression	93	47.1880			
Deviation from individual regressions within places (Rameswaram & Madras)	90	42.6448	0.4738	2.0546	253
Differences between regressions	1	0.2306	0.2306		
Deviation from total regression	91	42.8754			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Vizhingam)	57	27.3365	0.4795	4.6661	4.00
Differences between regressions	1	2.2374	2.2374		
Deviation from total regression	58	29.5739			
Deviation from individual regressions within places (Thangachimadam & Rameswaram Road)	96	82.0334	0.8545	1.6947	3.94
Differences between regressions	1	1.4482	1.4482		
Deviation from total regression	97	83.4816			
Deviation from individual regressions within places (Thangachimadam & Pudumadam)	98	61.6853	0.6290	1.0044	3.94
Differences between regressions	1	0.6318	0.6318		
Deviation from total regression	99	62.3171			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Thangachimadam & Madras)	96	57.6211	0.6002		
Differences between regressions	1	0.1638	0.1638	3.6642	253
Deviation from total regression	97	57.7849			
Deviation from individual regressions within places (Thangachimadam & Vizhingam)	63	42.3128	0.6716		
Differences between regressions	1	3.8969	3.8969	5.8024	3.99
Deviation from total regression	64	46.2097			
Deviation from individual regressions within places (Rameswaram Road & Pudumadam)	98	85.8171	0.8756		
Differences between regressions	1	2.8886	2.8886	3.2989	3.94
Deviation from total regression	99	88.7057			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram Road & Madras)	96	81.7529	0.8515	1.5128	3.94
Differences between regressions	1	1.2882	1.2882		
Deviation from total regression	97	83.0411			
Deviation from individual regressions within places (Rameswaram Road & Vishingam)	63	66.4446	1.0546	5.2515	3.99
Differences between regressions	1	5.5383	5.5383		
Deviation from total regression	64	71.9829			
Deviation from individual regressions within places (Pudumadam & Madras)	98	61.4048	0.6265	3.0940	3.94
Differences between regressions	1	1.9384	1.9384		
Deviation from total regression	99	63.3432			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Pudumadam & Vizhingam)	65	46.0965	0.7091	4.0599	3.99
Differences between regressions	1	2.8789	2.8789		
Deviation from total regression	66	48.9754			
Deviation from individual regressions within places (Madras & Vizhingam)	63	42.0323	0.6671	3.8052	3.99
Differences between regressions	1	2.5385	2.5385		
Deviation from total regression	64	44.5708			
SNOUT TO SECOND DORSAL:					
Deviation from individual regressions within places	251	218.3329	0.8698	1.1819	2.23
Differences among regressions	5	5.1401	1.0280		
Deviation from total regression	256	223.4730			

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
SNOUT TO VENTRAL:					
Deviation from individual regressions within places	251	131.3098	0.5231	5.2706	2.23
Differences among regressions	5	13.7856	2.7571		
Deviation from total regression	256	145.0954			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Thangachimadam)	90	40.5131	0.4501	1.4762	253
Differences between regressions	1	0.3049	0.3049		
Deviation from total regression	91	40.8180			
Deviation from individual regressions within places (Rameswaram & Rameswaram Road)	90	46.2238	0.5135	1.9579	3.94
Differences between regressions	1	1.0054	1.0054		
Deviation from total regression	91	47.2292			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Pudumadam)	92	37.4462	0.4070	18.2560	3.94
Differences between regressions	1	7.4302	7.4302		
Deviation from total regression	93	44.8764			
Deviation from individual regressions within places (Rameswaram & Madras)	90	34.4079	0.3823	19.0591	3.94
Differences between regressions	1	7.2863	7.2863		
Deviation from total regression	91	41.6942			
Deviation from individual regressions within places (Rameswaram & Vizhingam)	57	22.8968	0.4016	2.3535	4.00
Differences between regressions	1	0.9452	0.9452		
Deviation from total regression	58	23.8420			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Thangachimadam & Rameswaram Road)	96	61.6479	0.6421	1.6531	253
Differences between regressions	1	0.3884	0.3884		
Deviation from total regression	97	62.0363			
Deviation from individual regressions within places (Thangachimadam & Pudumadam)	98	52.8703	0.5394	9.6334	3.94
Differences between regressions	1	5.1963	5.1963		
Deviation from total regression	99	58.0666			
Deviation from individual regressions within places (Thangachimadam & Madras)	96	49.8320	0.5190	11.3516	3.94
Differences between regressions	1	5.8915	5.8915		
Deviation from total regression	97	55.7235			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Thangachimadam & Vizhingam)	63	38.3209	0.6082		
Differences between regressions	1	0.6748	0.6748	1.1095	3.99
Deviation from total regression	64	38.9957			
Deviation from individual regressions within places (Rameswaram Road & Pudumadam)	98	58.5810	0.5977		
Differences between regressions	1	1.2741	1.2741	2.1320	3.94
Deviation from total regression	99	59.8551			
Deviation from individual regressions within places (Rameswaram Road & Madras)	96	55.5427	0.5786		
Differences between regressions	1	3.0386	3.0386	5.2516	3.94
Deviation from total regression	97	58.5813			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram Road & Vizhingam)	63	44.0316	0.6989	2.2706	253
Differences between regressions	1	0.3078	0.3078		
Deviation from total regression	64	44.3394			
Deviation from individual regressions within places (Pudumadam & Madras)	98	46.7651	0.4771	2.2051	3.94
Differences between regressions	1	1.0521	1.0521		
Deviation from total regression	99	47.8172			
Deviation from individual regressions within places (Pudumadam & Vizhingam)	65	35.2540	0.5423	62.3333	253
Differences between regressions	1	0.0087	0.0087		
Deviation from total regression	66	35.2627			

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Madras & Vizhingam)	63	32.2157	0.5113	2.6644	253
Differences between regressions	1	0.1919	0.1919		
Deviation from total regression	64	32.4076			
SNOUT TO ANAL:					
Deviation from individual regressions within places	251	318.6501	1.2695	4.9288	2.23
Differences among regressions	5	31.2860	6.2572		
Deviation from total regression	256	349.9361			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Thangachimadam)	90	84.2506	0.9361	15.0413	3.94
Differences between regressions	1	14.0802	14.0802		
Deviation from total regression	91	98.3308			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Rameswaram Road)	90	122.8176	1.3646	317.3488	253
Differences between regressions	1	0.0043	0.0043		
Deviation from total regression	91	122.8219			
Deviation from individual regressions within places (Rameswaram & Pudumadam)	92	60.2142	0.6545	19.9899	3.94
Differences between regressions	1	13.0834	13.0834		
Deviation from total regression	93	73.2976			
Deviation from individual regressions within places (Rameswaram & Madras)	90	90.5638	1.0062	15.5446	3.94
Differences between regressions	1	15.6410	15.6410		
Deviation from total regression	91	106.2048			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Vizhingam)	57	56.1603	0.9852	209.6170	253
Differences between regressions	1	0.0047	0.0047		
Deviation from total regression	58	56.1650			
Deviation from individual regressions within places (Thangachimadam & Rameswaram Road)	96	159.3900	1.6603	3.9525	3.94
Differences between regressions	1	6.5625	6.5625		
Deviation from total regression	97	165.9525			
Deviation from individual regressions within places (Thangachimadam & Pudumadam)	98	96.7866	0.9876	5.6081	253
Differences between regressions	1	0.1767	0.1767		
Deviation from total regression	99	96.9633			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Thangachimadam & Madras)	96	127.1362	1.3243	3.1734	3.94
Differences between regressions	1	4.2026	4.2026		
Deviation from total regression	97	131.3388			
Deviation from individual regressions within places (Thangachimadam & Vizhingam)	63	92.7327	1.4719	1.5872	253
Differences between regressions	1	0.9273	0.9273		
Deviation from total regression	64	93.6600			
Deviation from individual regressions within places (Rameswaram Road & Pudumadam)	98	135.3536	1.3811	5.1565	3.94
Differences between regressions	1	7.1217	7.1217		
Deviation from total regression	99	142.4753			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram Road & Madras)	96	165.7032	1.7260	6.9629	3.94
Differences between regressions	1	12.0180	12.0180		
Deviation from total regression	97	177.7212			
Deviation from individual regressions within places (Rameswaram Road & Vizhingam)	63	131.2997	2.0841	4.3083	3.99
Differences between regressions	1	8.9791	8.9791		
Deviation from total regression	64	140.2788			
Deviation from individual regressions within places (Pudumadam & Madras)	98.	103.0998	1.0520	2.8070	3.94
Differences between regressions	1	2.9530	2.9530		
Deviation from total regression	99	106.0528			

—Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Pudumadam & Vizhingam)	65	68.6963	1.0568		
Differences between regressions	1	1.1704	1.1704	1.1074	3.99
Deviation from total regression	66	69.8667			
Deviation from individual regressions within places (Madras & Vizhingam)	63	99.0459	1.5721		
Differences between regressions	1	3.5001	3.5001	2.2263	3.99
Deviation from total regression	64	102.5460			
MAXIMUM DEPTH OF BODY:					
Deviation from individual regressions within places	251	270.3871	1.0772		
Differences among regressions	5	28.0211	5.6042	5.2025	2.23
Deviation from total regression	256	298.4082			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Thangachimadam)	90	73.8547	0.8206	1.3569	3.94
Differences between regressions	1	1.1135	1.1135		
Deviation from total regression	91	74.9682			
Deviation from individual regressions within places (Rameswaram & Rameswaram Road)	90	86.4494	0.9605	9.4921	3.94
Differences between regressions	1	9.1172	9.1172		
Deviation from total regression	91	95.5666			
Deviation from individual regressions within places (Rameswaram & Pudumadam)	92	120.6782	1.3117	8.3214	3.94
Differences between regressions	1	10.9152	10.9152		
Deviation from total regression	93	131.5934			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Madras)	90	77.4664	0.8607	15.9810	3.94
Differences between regressions	1	13.7549	13.7549		
Deviation from total regression	91	91.2213			
Deviation from individual regressions within places (Rameswaram & Vizhingam)	57	42.8384	0.7515	5.7820	4.00
Differences between regressions	1	4.3452	4.3452		
Deviation from total regression	58	47.1836			
Deviation from individual regressions within places (Thangachimadam & Rameswaram Road)	96	94.8541	0.9880	5.3648	3.94
Differences between regressions	1	5.3005	5.3005		
Deviation from total regression	97	100.1546			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Thangachimadam & Pudumadam)	98	129.0829	1.3171	4.4831	3.94
Differences between regressions	1	5.9048	5.9048		
Deviation from total regression	99	134.9877			
Deviation from individual regressions within places (Thangachimadam &Madras)	96	85.8711	0.8944	11.3289	3.94
Differences between regressions	1	10.1326	10.1326		
Deviation from total regression	97	96.0037			
Deviation from individual regressions within places (Thangachimadam & Vizhingam)	63	51.2431	0.8133	3.9688	3.99
Differences between regressions	1	3.2279	3.2279		
Deviation from total regression	64	54.4710			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram Road & Pudumadam)	98	141.6776	1.4456	15.8161	253
Differences between regressions	1	0.0914	0.0914		
Deviation from total regression	99	141.7690			
Deviation from individual regressions within places (Rameswaram Road & Madras)	96	98.4658	1.0256	1.7168	3.94
Differences between regressions	1	1.7608	1.7608		
Deviation from total regression	97	100.2266			
Deviation from individual regressions within places (Rameswaram Road & Vizhingam)	63	63.8378	1.0132	1.3743	253
Differences between regressions	1	0.7372	0.7372		
Deviation from total regression	64	64.5750			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Pudumadam & Madras)	98	132.6946	1.3540	2.0400	3.94
Differences between regressions	1	2.7622	2.7622		
Deviation from total regression	99	135.4568			
Deviation from individual regressions within places (Pudumadam & Vizhingam)	65	98.0666	1.5087	1.4858	253
Differences between regressions	1	1.0154	1.0154		
Deviation from total regression	66	99.0820			
Deviation from individual regressions within places (Madras & Vizhingam)	63	54.8548	0.8707	145.1166	253
Differences between regressions	1	0.0060	0.0060		
Deviation from total regression	64	54.8608			

TABLE 22

COMPARISON OF DIFFERENT BODY LENGTHS OF S. LEPTOLEPIS BY COVARIANCE ANALYSIS FROM RAMESWARAM, THANGACHIMADAM, RAMESWARAM ROAD AND PUDUMADAM DURING 1959

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
HEAD LENGTH:					
Deviation from individual regressions within places	172	96.9918	0.5639	4.6538	2.65
Differences among regressions	3	7.8729	2.6243		
Deviation from total regression	175	104.8647			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Thangachimadam)	76	26.9888	0.3551	1.6401	253
Differences between regressions	1	0.2165	0.2165		
Deviation from total regression	77	27.2053			
Deviation from individual regressions within places (Rameswaram & Rameswaram Road)	86	50.9200	0.5920	151.7948	253
Differences between regressions	1	0.0039	0.0039		
Deviation from total regression	87	50.9239			

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Pudumadam)	86	46.7704	0.5314	8.8543	3.94
Differences between regressions	1	4.7052	4.7052		
Deviation from total regression	87	51.4756			
Deviation from individual regressions within places (Thangachimadam & Rameswaram Road)	86	50.2214	0.5839	5.1354	253
Differences between regressions	1	0.1137	0.1137		
Deviation from total regression	87	50.3351			
Deviation from individual regressions within places (Thangachimadam & Pudumadam)	86	46.0718	0.5357	9.9503	3.94
Differences between regressions	1	5.3304	5.3304		
Deviation from total regression	87	51.4022			

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram Road & Pudumadam)	96	70.0030	0.7291	4.7351	3.94
Differences between regressions	1	3.4524	3.4524		
Deviation from total regression	97	73.4554			
SNOUT TO FIRST DORSAL:					
Deviation from individual regressions within places	172	115.0753	0.6690	2.8780	2.65
Differences among regressions	3	5.7764	1.9254		
Deviation from total regression	175	120.8517			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Thangachimadam)	76	29.0174	0.3818	1.4418	253
Differences between regressions	1	0.2648	0.2648		
Deviation from total regression	77	29.2822			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Rameswaram & Rameswaram Road)	86	44.2122	0.5140	4.7838	3.94
Differences between regressions	1	2.4589	2.4589		
Deviation from total regression	87	46.6711			
Deviation from individual regressions within places (Rameswaram & Pudumadam)	86	75.4351	0.8771	2.6229	253
Differences between regressions	1	0.3344	0.3344		
Deviation from total regression	87	75.7695			
Deviation from individual regressions within places (Thangachimadam & Rameswaram Road)	86	39.6402	0.4609	4.1494	3.94
Differences between regressions	1	1.9125	1.9125		
Deviation from total regression	87	41.5527			

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within places (Thangachimadam & Pudumadam)	86	70.8631	0.8239		
				2.5227	3.94
Differences between regressions	1	2.0785	2.0785		
Deviation from total regression	87	72.9416			
Deviation from individual regressions within places (Rameswaram Road & Pudumadam)	96	86.0579	0.8964		
				5.8985	3.94
Differences between regressions	1	5.2875	5.2875		
Deviation from total regression	97	91.3454			
SNOUT TO SECOND DORSAL:					
Deviation from individual regressions within places	172	198.4934	1.1540		
				1.4214	2.65
Differences among regressions	3	4.9211	1.6403		
Deviation from total regression	175	203.4145			

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
SNOUT TO VENTRAL:					
Deviation from individual regressions within places	172	81.3482	0.4729	1.2150	2.65
Differences among regressions	3	1.7239	0.5746		
Deviation from total regression	175	83.0721			
SNOUT TO ANAL:					
Deviation from individual regressions within places	172	252.2142	1.4663	2.9622	8.54
Differences among regressions	3	1.4852	0.4950		
Deviation from total regression	175	253.6994			
MAXIMUM DEPTH OF BODY:					
Deviation from individual regressions within places	172	143.6823	0.8353	1.2494	2.65
Differences among regressions	3	3.1311	1.0437		
Deviation from total regression	175	146.8134			

TABLE 23

SIGNIFICANCE AND NON-SIGNIFICANCE OF MORPHOMETRIC CHARACTERS OF S. LEPTOLEPIS BETWEEN YEARS FROM RAMESWARAM, THANGACHIMADAM, RAMESWARAM ROAD AND PUDUMADAM

Locality	Head length	Snout to first dorsal	Snout to second dorsal	Snout to ventral	Snout to anal	Maximum depth of body
Rameswaram:						
1957 v. 1958	NS	NS	NS	NS	S	S
1957 v. 1959	S	NS	NS	NS	NS	S
1958 v. 1959	S	NS	NS	NS	S	S
Thangachimadam:						
1957 v. 1958	NS	S	NS	NS	NS	S
1957 v. 1959	NS	S	NS	NS	NS	S
1958 v. 1959	NS	NS	NS	NS	NS	NS
Rameswaram Road:						
1958 v. 1959	S	NS	NS	NS	NS	NS
Pudumadam:						
1957 v. 1958	NS	S	NS	NS	NS	S
1957 v. 1959	NS	NS	NS	NS	NS	S
1958 v. 1959	NS	NS	NS	NS	NS	NS

NS = Non-significant

S = Significant

TABLE 24

SIGNIFICANCE AND NON-SIGNIFICANCE OF MORPHOMETRIC CHARACTERS OF *S. LEPTOLEPIS* BETWEEN PLACES DURING 1957, 1958 AND 1959

Locality	Head length			Snout to first dorsal			Snout to second dorsal		
	'57	'58	'59	'57	'58	'59	'57	'58	'59
Rameswaram v. Thangachimadam	S	S	NS	S	S	NS	NS	NS	NS
Rameswaram v. Rameswaram Road	--	S	NS	--	S	S	--	NS	NS
Rameswaram v. Pudumadam	S	NS	S	NS	NS	NS	NS	NS	NS
Rameswaram v. Madras	--	NS	--	--	NS	--	--	NS	--
Rameswaram v. Vizhingam	--	NS	--	--	S	--	--	NS	--
Thangachimadam v. Rameswaram Road	--	NS	NS	--	NS	S	--	NS	NS
Thangachimadam v. Pudumadam	NS	NS	S	S	NS	NS	NS	NS	NS
Thangachimadam v. Madras	--	S	--	--	NS	--	--	NS	--
Thangachimadam v. Vizhingam	--	S	--	--	S	--	--	NS	--
Rameswaram Road v. Pudumadam	--	NS	S	--	NS	S	--	NS	NS
Rameswaram Road v. Madras	--	NS	--	--	NS	--	--	NS	--
Rameswaram Road v. Vizhingam	--	NS	--	--	S	--	--	NS	--
Pudumadam v. Madras	--	NS	--	--	NS	--	--	NS	--
Pudumadam v. Vizhingam	--	NS	--	--	S	--	--	NS	--
Madras v. Vizhingam	--	NS	--	--	NS	--	--	NS	--

--Continued

Locality	Snout to ventral			Snout to anal			Maximum depth of body		
	'57	'58	'59	'57	'58	'59	'57	'58	'59
Rameswaram v. Thangachimadam	NS	NS	NS	NS	S	NS	S	NS	NS

--Continued

Locality	Snout to ventral			Snout to anal			Maximum depth of body		
	'57	'58	'59	'57	'58	'59	'57	'58	'59
Rameswaram v. Rameswaram Road	--	NS	NS	--	S	NS	--	S	NS
Rameswaram v. Pudumadam	NS	S	NS	NS	S	NS	S	S	NS
Rameswaram v. Madras	--	S	--	--	S	--	--	S	--
Rameswaram v. Vizhingam	--	NS	--	--	NS	--	--	S	--
Thangachimadam v. Rameswaram Road	--	NS	NS	--	S	NS	--	S	NS
Thangachimadam v. Pudumadam	NS	S	NS	NS	NS	NS	NS	S	NS
Thangachimadam v. Madras	--	S	--	--	NS	--	--	S	--
Thangachimadam v. Vizhingam	--	NS	--	--	NS	--	--	NS	--
Rameswaram Road v. Pudumadam	--	NS	NS	--	S	NS	--	NS	NS
Rameswaram Road v. Madras	--	S	--	--	S	--	--	NS	--
Rameswaram Road v. Vizhingam	--	NS	--	--	S	--	--	NS	--
Pudumadam v. Madras	--	NS	--	--	NS	--	--	NS	--
Pudumadam v. Vizhingam	--	NS	--	--	NS	--	--	NS	--
Madras v. Vizhingam	--	NS	--	--	NS	--	--	NS	--

NS = Non-significant
S = Significant

The results of the morphometric analyses of *Selaroides leptolepis* may be summarised as follows:

Head length: The comparison of the samples collected during the years 1957 & 1959, and 1958 & 1959 showed significant differences at Rameswaram. Similarly the samples of 1958 &

1959 were significantly different at Rameswaram Road.

The regressions of head length showed significant differences in the samples collected during 1957 between Rameswaram & Thangachimadam and Rameswaram & Pudumadam. During 1958, they were significantly different between Rameswaram & Thangachimadam, Rameswaram & Rameswaram Road, Thangachimadam & Madras and Thangachimadam & Vizhingam. In 1959 significant differences were observed in the samples between Rameswaram & Pudumadam, Thangachimadam & Pudumadam and Rameswaram Road & Pudumadam. The regression lines are plotted in Plate 1, Fig. 14 and Plate 2, Figs. 20 and 26.

Snout to first dorsal: The samples collected from Thangachimadam during 1957 when compared with 1958 and 1959 revealed significant differences. Similarly the samples of Pudumadam in 1957 & 1958 were also significantly different in regard to this character.

The comparison of regressions revealed that samples were significantly different between Rameswaram & Thangachimadam and Thangachimadam & Pudumadam in 1957. In 1958, significant differences were observed between the samples of Rameswaram & Thangachimadam, Rameswaram & Rameswaram Road, Rameswaram & Vizhingam, Thangachimadam & Vizhingam, Rameswaram Road & Vizhingam and Pudumadam &

Vizhingam. The differences persisted during 1959 between Rameswaram & Rameswaram Road, Thangachimadam & Rameswaram Road and Rameswaram Road & Pudumadam. The regressions are plotted in Plate 1, Fig.15 and Plate 2, Figs.21 and 27.

Snout to second dorsal: In regard to this character, the comparison of the regressions from year to year and from different centres within a year showed that samples were drawn from a homogeneous population. The regressions are plotted in Plate 2, Figs. 16, 22 and 28.

Snout to ventral: The regressions of the samples when compared from different years revealed that they did not differ significantly.

The comparison of the regressions showed that samples from different centres were drawn from a homogeneous population in 1957 and 1959, whereas significant differences were noticed during 1958 between the samples of Rameswaram & Pudumadam, Rameswaram & Madras, Thangachimadam & Pudumadam, Thangachimadam & Madras and Rameswaram Road & Madras. The regressions are given in Plate 2, Figs.17, 23 and 29.

Snout to anal: The samples showed significant differences between 1957 & 1958 and 1958 & 1959 at Rameswaram.

Regressions of the samples within 1957 and 1959 from different places when compared revealed that the differences were non-significant in regard to this character. In 1958 samples were significantly different between Rameswaram & Thangachimadam, Rameswaram & Rameswaram Road, Rameswaram & Pudumadam, Rameswaram & Madras, Thangachimadam & Rameswaram Road, Rameswaram Road & Pudumadam, Rameswaram Road & Madras and Rameswaram Road & Vizhingam. The regressions are plotted in Plate 2, Figs. 18, 24 and 30.

Maximum depth of body: The samples were significantly different between all the years at Rameswaram. Significant differences were also observed in the samples of Thangachimadam and Pudumadam between 1957 & 1958 and 1957 & 1959.

The analysis of this character showed that the regressions were significantly different between the samples of Rameswaram & Thangachimadam and Rameswaram & Pudumadam in 1957, between Rameswaram & Rameswaram Road, Rameswaram & Pudumadam, Rameswaram & Madras, Rameswaram & Vizhingam, Thangachimadam & Rameswaram Road, Thangachimadam & Pudumadam and Thangachimadam & Madras in 1958, while they did not show any significant difference within the samples of 1959. The regressions are plotted in Plate 2, Figs. 19, 25 and 31.

Meristic characters.

In order to test whether the samples were drawn from a homogeneous population from year to year, and from different centres within a year the meristic characters were analysed by the Analysis of Variance. The samples were first pooled together and analysed and in the event of their showing significant differences, they were then treated in combinations of two's. The details of the analyses are given in tables 25 to 34 and the final results are presented in tables 35 and 36.

TABLE 25

FREQUENCY DISTRIBUTION OF DORSAL AND ANAL FIN RAY COUNTS OF *S. LEPTOLEPIS* DURING 1957 FROM RAMESWARAM, THANGACHIMADAM AND PUDUMADAM

Locality	N	Number of fish having dorsal fin ray counts of:			
		23	24	25	26
Rameswaram	40	7	20	13	--
Thangachimadam	40	6	17	14	3
Pudumadam	38	4	17	16	1
		Number of fish having anal fin ray counts of:			
		19	20	21	22
Rameswaram	40	--	27	8	5
Thangachimadam	40	2	10	26	2
Pudumadam	38	1	17	16	4

TABLE 26

FREQUENCY DISTRIBUTION OF DORSAL AND ANAL FIN RAY COUNTS OF S. LEPTOLEPIS DURING 1958 FROM RAMESWARAM, THANGACHIMADAM, RAMESWARAM ROAD, PUDUMADAM, MADRAS AND VIZHINGAM

Locality	N	Number of fish having dorsal fin ray counts of:			
		23	24	25	26
Rameswaram	44	2	30	11	1
Thangachimadam	40	2	16	20	2
Rameswaram Road	50	1	22	20	7
Pudumadam	80	2	44	27	7
Madras	50	--	22	26	2
Vizhingam	17	--	10	6	1

Locality	N	Number of fish having anal fin ray counts of:					
		18	19	20	21	22	23
Rameswaram	44	--	--	20	21	3	--
Thangachimadam	40	--	--	12	20	8	--
Rameswaram Road	50	--	--	7	27	16	--
Pudumadam	80	1	--	23	47	9	--
Madras	50	--	--	15	26	8	1
Vizhingam	17	--	--	6	6	4	1

TABLE 27

FREQUENCY DISTRIBUTION OF DORSAL AND ANAL FIN RAY COUNTS OF S. LEPTOLEPIS DURING 1959 FROM RAMESWARAM, THANGACHIMADAM, RAMESWARAM ROAD AND PUDUMADAM

Locality	N	Number of fish having dorsal fin ray counts of:						
		21	22	23	24	25	26	27
Rameswaram	40	--	--	1	26	12	1	--
Thangachimadam	90	--	--	8	50	30	2	--
Rameswaram Road	96	--	--	2	46	43	5	--
Pudumadam	73	1	--	6	29	31	5	1

Locality	N	Number of fish having anal fin ray counts of:					
		18	19	20	21	22	23
Rameswaram	40	--	--	13	25	2	--
Thangachimadam	90	--	2	24	52	12	--
Rameswaram Road	96	1	1	24	58	12	--
Pudumadam	73	--	3	17	36	15	2

TABLE 28

ANALYSIS OF VARIANCE FOR DORSAL AND ANAL FIN RAYS OF *S. LEPTOLEPIS* WITHIN YEARS (1957, 1958 AND 1959) FROM RAMESWARAM

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
DORSAL FIN RAYS:					
Between years	2	0.6170	0.3085	1.2353	19.49
Within years	121	46.1250	0.3811		
Total	123	46.7420			
ANAL FIN RAYS:					
Between years	2	1.5319	0.7659	1.9185	3.07
Within years	121	48.3069	0.3992		
Total	123	49.8388			

TABLE 29

ANALYSIS OF VARIANCE FOR DORSAL AND ANAL FIN RAYS OF *S. LEPTOLEPIS* WITHIN YEARS (1957, 1958 AND 1959) FROM THANGACHIMADAM

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
DORSAL FIN RAYS:					
Between years	2	1.8994	0.9497	1.8997	3.04
Within years	167	83.4889	0.4999		
Total	169	85.3883			
ANAL FIN RAYS:					
Between years	2	0.8209	0.4104	1.1257	19.49
Within years	167	77.1556	0.4620		
Total	169	77.9765			

TABLE 30

ANALYSIS OF VARIANCE FOR DORSAL AND ANAL FIN RAYS OF *S. LEPTOLEPIS* WITHIN YEARS (1957 AND 1958) FROM RAMESWARAM ROAD

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
DORSAL FIN RAYS:					
Between years	1	0.5450	0.5450	1.2050	3.91
Within years	144	65.1262	0.4523		
Total	145	65.6712			
ANAL FIN RAYS:					
Between years	1	4.1921	4.1921	8.9613	3.91
Within years	144	67.3696	0.4678		
Total	145	71.5617			

TABLE 31

ANALYSIS OF VARIANCE FOR DORSAL AND ANAL FIN RAYS OF *S. LEPTOLEPIS* WITHIN YEARS (1957, 1958 AND 1959) FROM PUDUMADAM

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
DORSAL FIN RAYS:					
Between years	2	0.4066	0.2033	3.1406	19.49
Within years	188	120.0489	0.6385		
Total	190	120.4555			
ANAL FIN RAYS:					
Between years	2	2.9673	1.4836	2.5770	3.04
Within years	188	108.2474	0.5757		
Total	190	111.2147			

TABLE 32

ANALYSIS OF VARIANCE FOR DORSAL AND ANAL FIN RAYS OF *S. LEPTOLEPIS* FROM RAMESWARAM, THANGACHIMADAM AND PUDUMADAM DURING 1957

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
DORSAL FIN RAYS:					
Between places	2	1.1612	0.5806	1.0267	3.07
Within places	115	65.0422	0.5655		
Total	117	66.2034			
ANAL FIN RAYS:					
Between places	2	1.2736	0.6368	1.3225	3.07
Within places	115	55.3790	0.4815		
Total	117	56.6526			

TABLE 33

ANALYSIS OF VARIANCE FOR DORSAL AND ANAL FIN RAYS OF *S. LEPTOLEPIS* FROM RAMESWARAM, THANGACHIMADAM, RAMESWARAM ROAD, PUDUMADAM, MADRAS AND VIZHINGAM DURING 1958

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
DORSAL FIN RAYS:					
Between places	5	4.6350	0.9270	2.1315	2.23
Within places	275	119.5928	0.4349		
Total	280	124.2278			
ANAL FIN RAYS:					
Between places	5	8.5868	1.7173	3.4911	2.23
Within places	275	135.2994	0.4919		
Total	280	143.8862			

Since the character is significant at 5% probability level, it is analysed in combinations of two's.

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Between places (Rameswaram & Thangachimadam)	1	1.7181	1.7181		
Within places	82	36.0319	0.4394	3.9101	3.94
Total	83	37.7500			
Between places (Rameswaram & Rameswaram Road)	1	7.5073	7.5073		
Within places	92	37.8119	0.4109	18.2703	3.94
Total	93	45.3192			
Between places (Rameswaram & Pudumadam)	1	0.8581	0.8581		
Within places	122	53.8194	0.4411	1.9453	3.92
Total	123	54.6775			
Between places (Rameswaram & Madras)	1	1.9192	1.9192		
Within places	92	42.9319	0.4666	4.1131	3.94
Total	93	44.8511			
Between places (Rameswaram & Vizhingam)	1	1.8304	1.8304		
Within places	59	30.4319	0.5157	3.5493	4.00
Total	60	32.2623			
Between places (Thangachimadam & Rameswaram Road)	1	1.7423	1.7423		
Within places	88	40.9800	0.4656	3.7420	3.94
Total	89	42.7223			

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Between places (Thangachimadam & Pudumadam)	1	0.3375	0.3375	1.4308	254
Within places	118	56.9875	0.4829		
Total	119	57.3250			
Between places (Thangachimadam & Vizhingam)	1	0.1193	0.1193	5.1207	253
Within places	55	33.6000	0.6109		
Total	56	33.7193			
Between places (Rameswaram Road & Pudumadam)	1	4.7402	4.7402	10.3249	3.91
Within places	128	58.7675	0.4591		
Total	129	63.5077			
Between places (Rameswaram Road & Madras)	1	1.9600	1.9600	4.0122	3.94
Within places	98	47.8800	0.4885		
Total	99	49.8400			
Between places (Rameswaram Road & Vizhingam)	1	0.4111	0.4111	1.6981	253
Within places	65	45.3800	0.6981		
Total	66	45.7911			
Between places (Pudumadam & Madras)	1	0.3895	0.3895	1.2813	254
Within places	128	63.8875	0.4991		
Total	129	64.2770			

--Continued

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Between places (Pudumadam & Vizhingam)	1	0.6332	0.6332	1.1706	3.94
Within places	95	51.3875	0.5409		
Total	96	52.0207			
Between places (Madras & Vizhingam)	1	0.1269	0.1269	4.9093	253
Within places	65	40.5000	0.6230		
Total	66	40.6269			

TABLE 34

ANALYSIS OF VARIANCE FOR DORSAL AND ANAL FIN RAYS OF *S. LEPTOLEPIS* FROM RAMESWARAM, THANGACHIMADAM, RAMESWARAM ROAD AND PUDUMADAM DURING 1959

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
DORSAL FIN RAYS:					
Between places	3	3.3531	1.1177	2.2371	2.62
Within places	295	147.3894	0.4996		
Total	298	150.7425			
ANAL FIN RAYS:					
Between places	3	1.3933	0.4644	1.1014	8.54
Within places	295	150.9011	0.5115		
Total	298	152.2944			

TABLE 35

SIGNIFICANCE AND NON-SIGNIFICANCE OF MERISTIC CHARACTERS OF S. LEPTOLEPIS BETWEEN YEARS FROM RAMESWARAM, THANGACHIMADAM, RAMESWARAM ROAD AND PUDUMADAM

Locality		Dorsal fin rays	Anal fin rays
Rameswaram:			
1957 v. 1958	..	NS	NS
1957 v. 1959	..	NS	NS
1958 v. 1959	..	NS	NS
Thangachimadam:			
1957 v. 1958	..	NS	NS
1957 v. 1959	..	NS	NS
1958 v. 1959	..	NS	NS
Rameswaram Road:			
1958 v. 1959	..	NS	S
Pudumadam:			
1957 v. 1958	..	NS	NS
1957 v. 1959	..	NS	NS
1958 v. 1959	..	NS	NS

NS = Non-significant   S = Significant

TABLE 36

SIGNIFICANCE AND NON-SIGNIFICANCE OF MERISTIC CHARACTERS OF S. LEPTOLEPIS BETWEEN PLACES DURING 1957, 1958 AND 1959

Locality		Dorsal fin rays			Anal fin rays		
		'57	'58	'59	'57	'58	'59
Rameswaram v. Thangachimadam	..	NS	NS	NS	NS	NS	NS
Rameswaram v. Rameswaram Road	..	--	NS	NS	--	S	NS
Rameswaram v. Pudumadam	..	NS	NS	NS	NS	NS	NS
Rameswaram v. Madras	..	--	NS	--	--	S	--
Rameswaram v. Vizhingam	..	--	NS	--	--	NS	--
Thangachimadam v. Rameswaram Road	..	--	NS	NS	--	NS	NS
Thangachimadam v. Pudumadam	..	NS	NS	NS	NS	NS	NS
Thangachimadam v. Madras	..	--	NS	--	--	NS	--

--Continued

Locality		Dorsal fin rays '57	Dorsal fin rays '58	Dorsal fin rays '59	Anal fin rays '57	Anal fin rays '58	Anal fin rays '59
Thangachimadam v. Vizhingam	..	--	NS	--	--	NS	--
Rameswaram Road v. Pudumadam	..	--	NS	NS	--	S	NS
Rameswaram Road v. Madras	..	--	NS	--	--	S	--
Rameswaram Road v. Vizhingam	..	--	NS	--	--	NS	--
Pudumadam v. Madras	..	--	NS	--	--	NS	--
Pudumadam v. Vizhingam	..	--	NS	--	--	NS	--
Madras v. Vizhingam	..	--	NS	--	--	NS	--

NS = Non-significant S = Significant

The following interesting points can be brought out in connection with the meristic characters of *Selaroides leptolepis*:

Vertebral counts: The number of vertebrae being 24 (10+14) in all the fish examined, irrespective of the time and place of collection, this character was not analysed.

Dorsal fin rays: Samples collected from year to year and from different centres within a year did not show significant differences in their mean values.

Anal fin rays: The mean values of the samples, collected from Rameswaram Road, showed significant differences between 1958 & 1959.

The analysis of the mean values of this character did not reveal significant differences between the samples of 1957 and 1959; the differences were observed in 1958 between the samples of Rameswaram & Rameswaram Road, Rameswaram & Madras, Rameswaram Road & Pudumadam and Rameswaram Road & Madras.

The significance and non-significance of morphometric and meristic characters between the years and within a year at different places indicate that a character which may be helpful in separating the populations at any one centre in a given time, may or may not be applicable from year to year at the same place. Further the variable nature of the characters is a pointer that they may be used with caution in delimiting populations.

Discussion.

That populations resemble each other more if the distribution is closer to one another and as we go farther apart the differences become greater has been observed by De Sylva et al (1956), Julio (1958), Prasad (1958b) and many other workers. In the present study it was noticed that some of the characters were non-significant among the populations obtained from places situated far apart while others were significant. The converse i.e., populations from closely situated places exhibited characters which were at times significantly different and at other times not, was also true. In view of the fact that some of the differences persisted from year to year at the same place, it may be possible to infer that they give an indication of the existence of different populations. But taking into consideration the biannual spawning of the fish, this interpretation becomes somewhat difficult because the fish are recruited twice a year. At the time of the first spawning (January to March) the temperature and salinity in the neighbourhood of Mandapam vary from 23.5 to 30°C and 24.76 to 33.08 $^{\circ}$/oo respectively and at the time of second spawning (July-August to October) they range from 25.5 to 30.5°C and 33.04 to 37.45 $^{\circ}$/oo respectively (Prasad, 1958). This variation in temperature and salinity during the respective spawning seasons might have affected the nature of the different characters, particularly the meristic ones. Thus, it may be that the differences exhibited in the various characters from year to year from the same place are phenotypic only. Differences noticed from different places within a year may further be attributed to the different ecological conditions. Nevertheless, the results of the present investigation do reflect on the existence of certain distinct populations.

SECTION III

CHAPTER 6

FOOD AND FEEDING HABITS

Chacko (1949) and Chacko and Mathew (1956) while giving short accounts of the gross biological features of certain species of horse-mackerel described the food of these fishes from the Madras and the Kerala coasts respectively. Mahadevan (1950), Bapat and Bal (1952), Datar (1954) and Kuthalingam (1955 b) described the food of certain carangids from Madras and Bombay. Vijayaraghavan (1957) described the food of the larval and post-larval Decapterus russelli from the Madras coast. Tham Ah Kow (1950) gave an account of the food of Caranx species from the waters of the Singapore Straits and Soemarto (1958) described the food and behaviour of Decapterus species from Indonesia. Williams (1956) gave short accounts of certain aspects of the biology of carangoid fishes from East Africa.

Beyond the limits of the Indian Ocean, the works of Hatanaka and Murakawa (1958) on the food of Seriola quinqueradiata from Japan, of Lebour (1918, 1920) on European horse-mackerel from Cawsand Bay and that of McKenney et al (1958) on Caranx crysos from the Gulf of Caribbean merit special mention.

Pearse (1915, 1916) during his investigations on the food of shore fishes from Wisconsin estimated the percentage of each item of food by volume. Job (1940) in his investigations on the nutrition of Perches of the Madras coast and Sarojini (1954) for the analysis of food in Grey mullets followed the same method as described by Pearse (op. cit.). Bapat and Bal (1950, 1952) estimated the percentage of various food items by eye estimation in Clupeids and various other fishes from Bombay. Hynes (1950) gave a brief review of various methods for analysis of food constituents and followed the points method, for estimating the percentage composition of various organisms in the food of freshwater sticklebacks, as described by Swynnerton and Worthington (1940) and modified by Frost (1943). Bhimachar and George (1952) followed points method and number method for the estimation of food contents in Rastrelliger canagurta. Seshappa and Bhimachar (1955) followed the occurrence method for the determination of food items in case of Cynoglossus semifasciatus. Pillay (1952) gave a critical review of various methods used for analysis of food and is of the opinion that volumetric methods of analysis are most satisfactory. He further stated that the selection of any method depends on the nature of the food of the fish.

To analyse the food of Selaroides leptolepis, Points method was used. The percentage composition of each food item was calculated by allotting points based on the relative volume as determined by visual estimation. While allotting points the degree of fullness of the stomach as well as the size of the fish were taken into consideration. The degree of feeding was expressed by recording the stomachs as full, ¾ full, ½ full, ¼ full and empty. The full stomach was allotted twenty points, three quarters full - fifteen, half full - ten, quarter full - five and empty - zero points.

The percentage frequency of each food item was determined by the Occurrence method.

The food items were identified as far as possible up to the genera.

<u>Distribution of food items in the stomachs of *S. leptolepis* at different centres during different months.</u>

Since the material for examination was available from different centres, the work was so planned as to facilitate a comparative study of the food of the fish in the different localities.

Tables 37, 38 and 39 represent the distribution of various food items in the stomachs of *S. leptolepis* from Pudumadam, Rameswaram Road and Rameswaram respectively.

TABLE 37

PERCENTAGE OF DIFFERENT FOOD ITEMS IN THE STOMACH CONTENTS OF S. LEPTOLEPIS DURING DIFFERENT MONTHS AT PUDUMADAM

	1957							
	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
No. of fish examined	40	10	..	..	11	..	16	16
Food items								
Lucifer	46.06	--	..	..	--	..	--	28.76
Mysids	--	22.40	..	..	--	..	8.00	2.70
Acetes	0.56	6.40	..	..	100.00	..	26.50	34.52
Acartia	14.85	42.20	..	..	--	..	40.00	--
Euterpina	--	--	..	..	--	..	2.00	--
Oithona	--	--	..	..	--	..	--	--
Decapod larvae	0.25	--	..	..	--	..	0.50	--
Copepod eggs	--	--	..	..	--	..	--	--
Pteropod shells	--	--	..	..	--	..	--	--
Molluscan larvae	11.22	1.20	..	..	--	..	6.00	4.32
Fishes	18.25	12.50	..	..	--	..	10.00	16.74
Alcyonarian spicules	--	--	..	..	--	..	--	--
Foraminiferan shells	3.00	0.70	..	..	--	..	3.00	--
Filamentous algae	5.25	5.00	..	..	--	..	--	--
Diatoms	--	--	..	..	--	..	2.00	--
Sand grains	0.56	9.60	..	..	--	..	2.00	12.96

--Continued

	1958							
	Jan.	Feb.	March	April	May	June	July	Aug.
No. of fish examined	10	12	53	47	14	13	30	25
Food items								
Lucifer	21.50	25.40	56.00	--	1.30	--	--	34.90
Mysids	--	20.00	2.88	--	--	6.40	3.60	--
Acetes	41.00	25.60	8.62	--	--	88.20	83.00	7.90
Acartia	--	--	16.16	--	61.30	--	--	--
Euterpina	--	--	0.43	--	--	--	--	--
Oithona	--	--	0.43	--	--	--	--	--
Decapod larvae	--	1.00	0.50	--	--	--	--	--

--Continued

	1958							
	Jan.	Feb.	March	April	May	June	July	Aug.
No. of fish examined	10	12	53	47	14	13	30	25
Food items								
Copepod eggs	--	--	--	--	--	--	--	6.50
Pteropod shells	--	--	4.31	--	--	--	--	11.90
Molluscan larvae	--	--	1.28	--	--	--	--	--
Fishes	31.50	18.00	4.16	80.00	7.90	--	9.80	38.80
Alcyonarian spicules	--	--	0.43	--	--	--	--	--
Foraminiferan shells	2.00	2.00	0.64	--	--	--	--	--
Filamentous algae	--	--	3.04	--	--	--	--	--
Diatoms	--	2.00	--	--	--	--	--	--
Sand grains	4.00	6.00	1.12	20.00	29.50	5.40	3.60	--

--Continued

	1958				1959		
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
No. of fish examined	7	..	28	24	12	57	40
Food items							
Lucifer	--	..	30.10	28.05	78.61	29.81	57.72
Mysids	--	..	--	--	4.65	21.86	6.17
Acetes	100.00	..	39.80	59.73	13.95	3.74	2.82
Acartia	--	..	--	--	--	0.12	15.30
Euterpina	--	..	--	3.41	--	0.37	--
Decapod larvae	--	..	--	1.25	--	--	0.94
Molluscan larvae	--	..	--	0.73	--	--	--
Fishes	--	..	30.10	0.73	0.93	44.10	15.84
Foraminiferan shells	--	..	--	--	--	--	0.13
Filamentous algae	--	..	--	0.73	1.86	--	0.94
Diatoms	--	..	--	--	--	--	0.13
Sand grains	--	..	--	5.37	--	--	--

TABLE 38

PERCENTAGE OF DIFFERENT FOOD ITEMS IN THE STOMACH CONTENTS OF *S. LEPTOLEPIS* DURING DIFFERENT MONTHS AT RAMESWARAM ROAD

	1957 Dec.	1958 Jan.	Feb.	March	April	May to Nov.	Dec.
No. of fish examined	6	..	36	20	22	..	41
Food items							
Lucifer	--	..	4.80	77.28	72.09	..	26.65
Mysids	27.50	..	14.00	--	7.44	..	--
Acetes	--	..	48.57	--	3.46	..	59.24
Acartia	--	..	--	5.10	--	..	--
Euterpina	--	..	--	2.00	--	..	--
Oithona	--	..	--	3.20	--	..	--
Decapod larvae	--	..	0.23	--	--	..	--
Molluscan larvae	20.50	..	--	0.57	--	..	1.70
Fishes	7.50	..	20.40	8.00	17.01	..	10.01
Alcyonarian spicules	2.50	..	--	0.57	--	..	--
Foraminiferan shells	2.00	..	1.40	--	--	..	--
Filamentous algae	2.50	..	4.40	2.30	--	..	--
Diatoms	--	..	1.30	--	--	..	--
Sand grains	37.50	..	4.90	0.41	--	..	2.40

--Continued

		1959 Jan.	Feb.	March	April
No. of fish examined		4	72	32	20
Food items					
Lucifer	..	63.75	24.32	72.41	21.64
Mysids	..	20.00	30.27	6.85	16.06
Acetes	..	2.50	15.77	0.37	0.98
Decapod larvae	..	--	0.16	--	0.33
Copepod eggs	..	7.50	--	--	--
Pteropod shells	..	--	4.22	--	--
Molluscan larvae	..	--	0.24	--	0.33
Fishes	..	6.25	25.02	15.37	60.66
Sand grains	..	--	--	5.00	--

TABLE 39

PERCENTAGE OF DIFFERENT FOOD ITEMS IN THE STOMACH CONTENTS OF *S. LEPTOLEPIS* DURING DIFFERENT MONTHS AT RAMESWARAM

	1957 June	1957 July	1957 Aug.	Sept. 1957 to April 1958	1958 May	1958 June to Aug.	1958 Sept.
No. of fish examined	44	14	15	..	31	..	8
Food items							
Lucifer	2.12	4.00	--	..	0.42	..	50.00
Mysids	--	--	8.20	..	0.84	..	--
Acetes	1.88	9.68	81.02	..	--	..	--
Acartia	46.00	39.60	8.40	..	55.58	..	--
Euterpina	4.12	5.41	--	..	5.05	..	--
Oithona	2.75	7.56	--	..	16.63	..	--
Decapod larvae	27.38	5.00	--	..	1.89	..	--
Centropages	2.00	--	--	..	0.84	..	--
Pseudodiaptomus	0.25	--	--	..	--	..	--
Corycaeus	0.37	--	--	..	--	..	--
Cypris larvae	--	--	--	..	0.84	..	--
Pteropod shells	--	--	--	..	--	..	41.40
Molluscan larvae	7.50	15.37	--	..	10.53	..	--
Fishes	2.75	3.26	2.04	..	4.21	..	8.60
Foraminiferan shells	0.12	0.54	--	..	--	..	--
Filamentous algae	0.50	2.00	--	..	--	..	--
Diatoms	0.25	--	--	..	--	..	--
Sand grains	2.00	7.58	0.34	..	3.16	..	--

In 1957 the specimens for examination from Pudumadam (table 37) were available during May, June, September, November and December. Crustaceans formed the main item of the food - *Acetes*, *Lucifer* and *Acartia* being the most important among them.

Molluscan larvae and shells contributed a little share to the food of the fish.

Fishes (Anchoviella) were next in importance to crustaceans and were common in May, June, November and December.

A certain amount of plant material viz. filamentous algae (Hypnea, Sarconema and Enteromorpha) and diatoms (Coscinodiscus, Navicula and Leptocylindrus) was also recorded in some months.

During 1958, the material was available in all the months except October. Lucifer occurred from January to March, May, August, November and December in different proportions with the peak in March. A comparison of May 1957 and 1958 shows that Lucifer formed a very low percentage of food in 1958, whereas they remained almost at the same level in December of each year. Mysids were recorded during February, March, June and July with the maximum of 20 per cent in February. Acetes was an important item of food throughout the year with the exception of March and August. In September of 1957 and 1958 it formed the entire food of the fish and recorded an increase in June, November and December 1958 over 1957. Acartia occurred in March and May, its proportion being greater in May 1958. Copepod eggs were observed in August only. Euterpina, Oithona and decapod larvae were of minor importance.

Molluscan larvae and shells occurred in March and December and formed a negligible portion of the food. Pteropods were present in March and August.

Juveniles of Anchoviella formed the major item of the food during January to May, July and August, and November-December.

Filamentous algae were noticed in March and December, and diatoms in February.

Foraminiferan shells and sand grains were of minor importance.

In 1959 fish were examined in January, February and March. Attempts were made to collect the fish in April also but without any success.

Lucifer occurred in greater proportion in January and February 1959 as compared to 1958 and was almost at the same level in March of each year. Mysids did not show any appreciable increase in February 1959 as compared to February 1958, but an increase was recorded in March 1959. Acetes occurred in lesser amount in the food as compared to 1958. Acartia was noticed in a negligible quantity in February but was more or less at the same level in March 1958 and 1959. Euterpina and decapod larvae were much less common in the food as compared to other items.

Fishes showed a decrease in January and increase in February and March when compared to the same months in 1958.

Filamentous algae were recorded in January and March and diatoms in March only.

Table 38 indicates the distribution of various food items in the stomachs of the fish at Rameswaram Road. Fish were available during December 1957, February to April and December 1958 and January to April 1959.

In December 1957 when only six specimens were available for examination, Mysids, molluscan larvae, fishes, Alcyonarian spicules, foraminiferan shells, filamentous algae and sand grains were recorded.

In 1958, Lucifer was present throughout -- the minimum in February and the maximum in March. Mysids and Acetes occurred in February and April, the latter was also recorded in December. Of the other crustaceans, Acartia was the most favoured item in March.

Molluscan larvae showed a considerable decline in December when compared to the same month in 1957.

Fishes occurred in all the four months showing an increase in December 1958 over 1957.

Alcyonarian spicules, foraminifera, and sand grains were of minor importance. Filamentous algae and diatoms were somewhat prominent, the former in February and March and the latter in February only.

In 1959 Lucifer, Mysids, Acetes and fishes were common in all the months. Of these Lucifer was most common in January and March, Mysids in February and fishes in April.

A comparison with 1958 reveals that decrease of Lucifer in February 1958 is compensated by an increase of Acetes in that month and an increase in fish diet compensates the decrease of Lucifer in April 1959.

Decapod and molluscan larvae were negligible in the diet. Pteropod shells occurred in February only.

Food analysis of specimens collected from Rameswaram is presented in table 39. Due to irregular timings and fluctuations in fishery, it was not possible to collect the fish in all the months. Hence, examination of fish was possible only during June, July and August in 1957 and May and September in 1958.

Lucifer was less common in June and July 1957 and May 1958, Mysids were recorded only in August 1957 and May 1958, whereas Acetes occurred in June, July and August 1957. Acartia occurred in fairly a good percentage in all the months except September 1958 when it was totally absent.

Of the other crustaceans, <u>Euterpina</u>, <u>Oithona</u> and decapod larvae were of greater importance than <u>Centropages</u>, <u>Pseudodiaptomus</u>, <u>Corycaeus</u> and cypris larvae.

Pteropod shells formed 41.40 per cent of the food in September 1958, the highest ever recorded from any other place during the course of this investigation. Molluscan larvae were common during June and July 1957 and May 1958.

Fishes occurred in all the months -- maximum being in September 1958.

Examination of fish from Thangachimadam did not reveal the presence of any food in their stomachs except for a few fish scales.

<u>Occurrence of food organisms in different size groups.</u>

A total of 830 fish was examined from Pudumadam, Rameswaram Road and Rameswaram. Fish examined from Thangachimadam are not included in this analysis since the stomachs were invariably empty except for a few fish scales. A sample of 50 fish was procured from Madras (east coast) and another of 18 from Vizhingam (west coast) for a comparative study of the food contents.

Specimens less than 5.0 cm. were rare in the catches and hence the food of smaller individuals could not be examined. A single specimen, 4.5 cm. in length was collected from the shore-seine catches and attempts to collect more individuals under light-fishing also proved futile.

Fish were grouped at 1 cm. interval. The percentage occurrence of different items of food in various size groups is given in table 40. The relative importance of the important items is represented graphically in Plate 2, Fig.32 and Plate 3, Fig.33.

TABLE 40

PERCENTAGE OCCURRENCE OF FOOD ITEMS IN THE STOMACHS OF S. LEPTOLEPIS IN VARIOUS SIZE GROUPS

Size groups (cm.)	No.of fish examined	Lucifer	Mysids	Acetes	Acartia	Euterpina	Oithona
4.1-5.0	1	--	--	--	100.00	100.00	100.00
5.1-6.0	13	--	--	--	100.00	69.23	53.85
6.1-7.0	45	15.56	--	15.56	95.56	55.56	51.11
7.1-8.0	37	16.22	16.22	27.03	72.97	32.43	24.32
8.1-9.0	55	25.45	3.64	60.00	18.18	10.91	5.45
9.1-10.0	83	45.78	19.28	60.24	28.92	6.02	2.41
10.1-11.0	179	64.80	27.37	28.49	18.99	2.79	1.68
11.1-12.0	186	65.59	31.18	32.80	8.60	--	--
12.1-13.0	155	65.81	61.94	54.19	2.58	0.64	--
13.1-14.0	71	66.20	50.70	50.70	5.63	--	--
14.1-15.0	5	60.00	40.00	40.00	--	--	--

--Continued

Size groups (cm.)	No.of fish exa-mined	Decapod larvae	Centropages	Pseudodiaptomus	Corycaeus	Cypris larvae	Copepod eggs
4.1-5.0	1	100.00	--	--	--	--	--
5.1-6.0	13	76.92	7.70	7.70	7.70	7.70	--
6.1-7.0	45	66.67	22.22	4.44	4.44	4.44	--
7.1-8.0	37	43.24	--	--	--	2.70	--
8.1-9.0	55	9.09	--	--	--	--	--
9.1-10.0	83	10.84	--	--	--	--	6.02
10.1-11.0	179	5.59	--	--	--	--	7.82
11.1-12.0	186	4.84	--	--	--	--	1.61
12.1-13.0	155	5.81	--	--	--	--	2.58
13.1-14.0	71	5.63	--	--	--	--	2.82
14.1-15.0	5	20.00	--	--	--	--	--

--Continued

Size groups (cm.)	No.of fish exa-mined	Ptero-pod shells	Mol-luscan larvae	Fishes	Alcyo-narian spi-cules	Fora-mini-feran shells	Fila-men-tous algae	Dia-toms
4.1-5.0	1	--	100.00	--	--	--	--	--
5.1-6.0	13	--	84.62	15.38	--	--	15.38	--
6.1-7.0	45	--	80.00	22.22	--	4.44	13.33	8.89
7.1-8.0	37	--	59.46	29.73	--	13.51	13.51	5.40

--Continued

Size groups (cm.)	No. of fish examined	Pteropod shells	Molluscan larvae	Fishes	Alcyonarian spicules	Foraminiferan shells	Filamentous algae	Diatoms
8.1-9.0	55	--	14.54	29.09	--	5.45	9.09	--
9.1-10.0	83	8.43	26.51	43.37	--	8.43	19.28	1.20
10.1-11.0	179	13.41	12.29	59.78	1.68	4.47	6.14	1.68
11.1-12.0	186	5.91	9.14	62.90	1.61	3.76	10.22	0.54
12.1-13.0	155	1.94	12.90	64.52	0.64	8.39	20.64	3.22
13.1-14.0	71	2.82	9.86	100.00	--	12.68	16.90	5.63
14.1-15.0	5	--	--	60.00	--	--	--	--

It may be seen from table 40 that *Lucifer* was not recorded from 4.1 to 6.0 cm. but occurred in all other sizes. Mysids were restricted from 7.1 to 15.0 cm. groups. *Acetes*, like *Lucifer*, occurred in all the sizes above 6.0 cm. *Acartia* was recorded in all the sizes except 14.1 to 15.0 cm., its occurrence being much more common in the younger individuals than in the older ones. *Euterpina* and *Oithona* were of common occurrence from the young to 11.0 cm., the former also occurring in a very low percentage in 12.1 to 13.0 cm. Decapod larvae were recorded from all the groups. *Centropages*, *Pseudodiaptomus*, *Corycaeus* and cypris larvae were of rare occurrence in the smaller individuals. They were completely absent in the older ones. Copepod eggs were noticed from 9.1 to 14.0 cm.

Molluscan larvae (Pteria) and shells were recorded from all the sizes except the last group, whereas Pteropod shells occurred from 9.1 to 14.0 cm.

Fishes and fish scales were recorded from all the groups except 4.1 to 5.0 cm. They, like Lucifer, reached their maximum in 13.1 to 14.0 cm.

Foraminiferan shells were maximum in 7.1 to 8.0 cm. while Alcyonarian spicules in 10.1 to 11.0 cm.

Of the filamentous algae (Hypnea, Sarconema and Enteromorpha) and diatoms (Coscinodiscus, Rhabdonema, Navicula and Leptocylindrus) the former occurred more frequently than the latter.

Relation with plankton.

Qualitative analysis of the plankton collected from the Gulf of Mannar at fortnightly intervals was made and the results are summarized below:-

Lucifer. They were common during the months of May, June, September, November and December 1957 but less common in July and August. In 1958, they were common during March to June, November and December but showed a decline in the months of January, February, July and September. During January to April 1959, a similar picture to 1958 was observed.

Acartia. From May 1957 it was common in the collections with the exception of September and October and showed somewhat similar trend in 1958. It was also common from January to April 1959.

<u>Decapod larvae</u>. They were less common during the months of September and October 1957 and July and October 1958 as compared to the rest of the months.

<u>Pteropod shells</u>. Their occurrence was seasonal and they were common from August to November 1957, January to March, September and November 1958 and January to March 1959.

<u>Molluscan larvae</u>. They were common in all the months except June 1957, February, April and June 1958.

<u>Diatoms</u>. They were present in all the months with the peak in October and November and sometimes plenty in December.

A comparison of tables 37 to 40 with the plankton observations leads to the conclusion that the occurrence and the extent of distribution of the food items in the stomachs of <u>S. leptolepis</u> have a relationship with their distribution in the plankton in different months. Table 40 indicates that in the lower size groups <u>Acartia</u>, <u>Euterpina</u>, <u>Oithona</u>, decapod larvae and molluscan larvae constitute favourite food and as the fish grows their occurrence tends to decrease and the fish eats more and more of <u>Lucifer</u>, <u>Acetes</u>, Mysids and fishes. Thus, as the fish grows it shows a tendency to feed on the bigger items. It is interesting to point out here that on several occasions the stomachs were noticed to have either Lucifer or Acetes or Mysids or fishes only.

Degree of feeding.

Table 41 presents the state of the stomach (in percentage) in different degrees of fullness from May 1957 to May 1959. Fishes labelled as full, $\frac{3}{4}$ full and $\frac{1}{2}$ full were considered to have fed actively while those designated as $\frac{1}{4}$ full showed less feeding.

TABLE 41

STATE OF THE STOMACH (IN PERCENTAGE) IN DIFFERENT DEGREES OF FULLNESS IN S. LEPTOLEPIS IN DIFFERENT MONTHS FROM PUDUMADAM, RAMESWARAM ROAD, RAMESWARAM AND THANGACHIMADAM

					1957				1958
	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
PUDUMADAM									
Full	86.6	70.0	--	--	18.2	--	75.0	12.5	100.0
$\frac{3}{4}$ full	8.4	--	--	--	27.3	--	6.3	37.5	--
$\frac{1}{2}$ full	5.0	10.0	--	--	18.2	--	12.4	12.5	--
$\frac{1}{4}$ full	--	10.0	--	--	36.3	--	--	37.5	--
Empty	--	10.0	--	--	--	--	6.3	--	--
RAMESWARAM ROAD									
Full	--	--	--	--	--	--	--	--	--
$\frac{3}{4}$ full	--	--	--	--	--	--	--	--	--
$\frac{1}{2}$ full	--	--	--	--	--	--	--	50.0	--
$\frac{1}{4}$ full	--	--	--	--	--	--	--	50.0	--
RAMESWARAM									
Full	--	90.9	85.8	92.6	--	--	--	--	--
$\frac{3}{4}$ full	--	--	7.1	7.4	--	--	--	--	--
$\frac{1}{2}$ full	--	--	7.1	--	--	--	--	--	--
$\frac{1}{4}$ full	--	--	--	--	--	--	--	--	--
Empty	--	9.1	--	--	--	--	--	--	--
THANGACHIMADAM									
Empty*	100.0	100.0	100.0	100.0	100.0	100.0	--	--	--

--Continued

	1958							
	Feb.	March	April	May	June	July	Aug.	Sept.
PUDUMADAM								
Full	--	18.9	--	21.5	12.0	33.3	76.0	57.1
¾ full	--	18.9	--	7.1	24.0	10.0	24.0	--
½ full	--	37.8	2.1*	42.8	8.0	30.0	--	14.3
¼ full	75.0	22.6	--	28.6	56.0	20.0	--	28.6
Empty	25.0	1.8	97.9*	--	--	6.7	--	--
RAMESWARAM ROAD								
Full	100.0	--	95.5	--	--	--	--	--
¾ full	--	25.0	--	--	--	--	--	--
½ full	--	35.0	4.5	--	--	--	--	--
¼ full	--	40.0	--	--	--	--	--	--
RAMESWARAM								
Full	--	--	--	61.3	--	--	--	100.0
¾ full	--	--	--	6.5	--	--	--	--
½ full	--	--	--	19.3	--	--	--	--
¼ full	--	--	--	12.9	--	--	--	--
THANGACHIMADAM								
Empty*	--	100.0	100.0	100.0	100.0	100.0	100.0	100.0

--Continued

	1958			1959				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
PUDUMADAM								
Full	--	58.0	70.8	75.0	45.6	82.5	--	--
¾ full	--	42.0	--	8.3	12.3	7.5	--	--
½ full	--	--	29.2	16.7	22.8	10.0	--	--
¼ full	--	--	--	--	17.5	--	--	--
Empty	--	--	--	--	1.8	--	--	--
RAMESWARAM ROAD								
Full	--	--	73.2	100.0	68.0	56.3	45.0	--
¾ full	--	--	7.3	--	15.3	28.1	20.0	--
½ full	--	--	14.6	--	13.9	12.5	30.0	--
¼ full	--	--	4.9	--	2.8	3.1	5.0	--
RAMESWARAM			No data					
THANGACHIMADAM								
Empty*	100.0	100.0	--	--	--	100.0	100.0	100.0

* Fish were caught at night.

It may be seen from table 41 that the occurrence of empty stomachs was much less at Pudumadam, Rameswaram Road and Rameswaram, but very common at Thangachimadam. In April 1958 high percentage of empty stomachs was recorded from Pudumadam which was presumably due to the difference in time of collection. The occurrence of ¼ full stomachs in greater proportion in certain months in one year and much less in other at different centres in the same months may well be attributed to the difference in time of fishing.

Feeding in relation to sexual cycle.

Though mature fish continue to occur throughout the year, the concentration of those individuals can be noticed only during February, March, August and September, immediately followed by spent, spent recovering and juvenile stages of the fish. It can be noticed from the table for Pudumadam (table 37) that the fish collected during September 1957, and March, August and September 1958 and from January to March 1959 had fed actively during the spawning season. Similarly, the table for Rameswaram Road (table 38) indicates the high degree of feeding in February and March 1958 and 1959. The observations from Rameswaram (table 39) further confirm that the fish do not stop feeding or show a sign of cessation of feeding during spawning season. Here it is worthwhile to mention that three specimens (all female) collected in Stage V* in August 1958 had full

* Refer to chapter 9.

stomachs containing Lucifer, Acetes and juveniles of Anchoviella. It can be further seen from table 40 that there is no change in the food of fish in different stages of maturity. The fish which attains a size of 8.7 cm. at first maturity continues to feed on the same items of food even after it has spawned. The proportions of different items, however, may vary.

Discussion.

For the purpose of comparison other carangids viz. Caranx melampygus, C. sexfasciatus, Selar kalla and S. mate were examined. Of these, the last two were caught and collected at night from Mandapam and Thangachimadam. On examination they had nothing in their stomachs except for a few fish scales showing similar results as in S. leptolepis. A sample of 18 fish of S. leptolepis examined from Vizhingam (west coast) caught at night in bag-nets revealed a similar condition. The results were in conformity with the earlier observations and help to establish that the fish most probably do not feed at night. A similar collection from bag-nets from Madras during day at 2 P.M. revealed the presence of Lucifer appendages, Mysids, Acartia, Decapod larvae, Labidocera, Pteropod shells, fishes and molluscan larvae in their stomachs. The stomachs of these fish were only ¼ full which was due to the time of catching the fish. Examination of the stomachs of S. leptolepis from the shore-seine collections at night from Pudumadam also did not reveal the presence of food contents, except for a few fish scales, which is an indication that the fish had fed long ago. This explains the higher percentage (97.9) of empty stomachs in April 1958. The absence of food in the stomachs of S. leptolepis caught at night can be due to one of two possible causes: 1. Absence of feeding activity at night. 2. Regurgitation by the fish when hauled up.

To investigate these possibilities a critical examination of the stomach contents of the fish was made from Pudumadam, Rameswaram Road and Rameswaram. Fish were taken from different hauls at different periods of day. It was found that fish caught till about 8 A.M. contained little food and those caught after 8 A.M. had stomachs in different degrees of fullness. Those caught at about 10 A.M. had full stomachs and the various items of food were easily identifiable due to incomplete digestion. The absence of food in the stomachs was, thus, not due to regurgitation but due to difference in time of catching the fish.

Bhattacharyya (1957) in the larval and post-larval herring, and Qasim (1957) in Blennius pholis, and Hatanaka and Murakawa (1958) in Seriola quinqueradiata observed that these fishes stop feeding at night. Bhattacharyya (op. cit.) conducted experimental feeding and found that light plays an important role in the feeding of larval and post-larval herring and that with the approach of darkness the feeding activity slows down. Hatanaka and Murakawa (op. cit.) remarked that the rates of empty stomachs in S. quinqueradiata varied from 0 to 80 per cent and 31 per cent in an average which was probably due to the time of collection being at dawn and to the non-feeding habits at midnight.

It appears that the feeding behaviour of S. leptolepis is similar to that of the above fishes.

Caranx sexfasciatus and C. melampygus were collected from shore-seines during day, the former had only juveniles of Anchoviella in their stomachs while in the latter the stomachs were full of Leiognathus, Anchoviella, Acetes, Mysids and Sepia. An interesting feature was observed in C. sexfasciatus which were also caught at 3 A.M. in shore-seines. Contrary to the expectations, the stomachs were full and contained Sardinella, Ilisha and Anchoviella. In one fish, in addition to these items a single specimen of Squilla and Selar malam (carangid) each were also observed. The occurrence of cannibalism is an interesting feature in this fish.

Vijayaraghavan (1957) described the food of larval and post-larval Decapterus russelli from the Madras coast and stated that the food of 23.6 to 26.4 mm. size consisted of Oithona, Pseudodiaptomus, Acartia, Temora, Labidocera, young prawns, molluscan and teleostean larvae. In the present investigation it was noticed that the fish when young preferred to feed on Acartia, Euterpina, Oithona, Decapod and molluscan larvae. Pseudodiaptomus, Centropages, Corycaeus and Cypris larvae were also noticed in the younger specimens although these occasionally did include Lucifer, Acetes, Mysids and fish scales. It can be safely concluded from table 40 that as the fish grows, Lucifer, Mysids, Acetes and fish juveniles are taken more often than any other item. Thus a definite change of food from the younger to the older size groups can be made out.

Tham Ah Kow (1950) examined 108 specimens of Caranx leptolepis from the Singapore Straits. His results cover a range of 40 to 115 mm. and according to him the fish feeds more 'heavily' on calanids, Mysids and Decapod larvae than on Cypris larvae, Amphipods, Alpheid larvae and post-larval fishes whilst Ostracods, Acetes, Lucifer, Leptochela and Brachyuran larvae are taken occasionally. His table 19 indicates that the fish feeds 'heavily' in May only and 'medium' type of feeding was observed in January, August, September and October whilst in November there was a 'slight' feeding and stomachs were empty in the months of March, April, June, July and December. It should be pointed out here that during the month of May when he (Tham Ah Kow) noticed 'heavy' feeding, he examined only 16 specimens which covered a range of 40 to 100 mm. Due to the small number of specimens examined by him in this range, it is possible that the juveniles were more in this group than the adults.

The presence of zooplankton and juveniles of _Anchoviella_ in major quantities in the food of _S. leptolepis_ from the Indian waters and occurrence of filamentous algae and diatoms only occasionally lead one to infer that this fish is mainly carnivorous, supplementing its food with phytoplankton according to their availability as against the view of Tham Ah Kow who concludes that it feeds selectively on zooplankton. In this connection it is of interest to note that the occurrence of plant material in the food of carangids has not been mentioned by Lebour (1918, 1920), Chacko (1949), Mahadevan (1950), Datar (1954) and Vijayaraghavan (1957). However, Kuthalingam (1955 b) and Chacko and Mathew (1956) do refer to the occurrence of very small amount of vegetable matter in the food of Indian horse-mackerel. Algal material has also been reported by Thomson (1959) in _Usacaranx nobilis_.

CHAPTER 7

PARASITES

Trematode parasites of the genera Contracaecum and Cucullanus were recorded from the ovaries of Selaroides leptolepis and one specimen of the former was also collected from the outer surface of the pyloric caeca . These parasites were of frequent occurrence during the spawning seasons and each fish had one parasite. ? at least Specimens examined from different centres were equally affected by the parasites and the ovaries did not show any visual distortion. They were not recorded from testes.

In this connection it may be mentioned that from the European waters Nicoll (1914) described four types of trematod parasites in Trachurus trachurus occurring in various parts of the alimentary canal. Of the four parasites described by him, Tergestia laticollis was of frequent occurrence in the rectum.

CHAPTER 8

LENGTH-WEIGHT RELATIONSHIP

The length-weight curve of fishes generally indicates that an increase in length is accompanied by a much more rapid increase in weight. Thus the weight of fishes may be considered a function of the length and since weight is a measure of volume while length is a linear measure, the weight of fishes is said to increase approximately as the cube of the length and can be expressed by the formula $W = a\ L^3$, where W = weight, a = constant, and L = length. Such a formula can be applied if form and specific gravity are constant throughout life and thus serve as the basis for the calculation of unknown weights of fish of known lengths or to determine the lengths of fish of known weights.

Le Cren (1951) has pointed out that the general parabola $W = a\ L^n$ gives better relation than the cubic parabola $W = a\ L^3$. Le Cren (op. cit.) further stated that the formula $W = a\ L^n$ besides providing a means for calculating weight from length, and a direct way of converting logarithmic growth-rates calculated on lengths into growth-rates for weight, may also give indications of taxonomic differences and events in the life history, such as metamorphosis and the onset of maturity. The value of exponent 'n' usually lies between 2.5 and 4 (Hile, 1936; and Martin, 1949) and for an ideal fish which maintains the same shape n = 3 (Allen, 1938).

For the study of the length-weight relationship of <u>Selaroides leptolepis</u>, the equation of the form of general parabola $W = a L^n$ was used where 'W' represents weight of fish in grams, 'L', the fork length in centimeters, and 'a', a constant and 'n' an exponent to which 'L' can be raised.

The fish, as soon as they were brought from the field, were first measured and then the excessive moisture was removed from each fish by pressing the latter in between two blotting papers and weights were noted down for individual fish. In some fish, gutted weight was also taken (the entire alimentary canal and its associated organs were removed).

Samples of fish collected during different months of 1957 and 1958 were studied from all the centres of observation. The observed values of lengths and weights were transformed to logarithmic values and the equations were calculated by the method of least squares. Males and females in each month were treated separately, and those collected from Pudumadam during May 1957 were analysed by the method of Analysis of Covariance. The relevant details are given in tables 42 to 44. It may be seen from table 44 that males and females do not differ significantly. The data were then pooled for each month and a common value of 'n' was found out. Table 45 gives the values of 'n' for males and females separately and after pooling the data from May 1957 to October 1957 and April 1958 for Thangachimadam, and ~~November~~ May 1957 to March 1958 for Pudumadam.

TABLE 42

STATISTICS OF THE LENGTH-WEIGHT RELATIONSHIP OF MALES AND FEMALES

Sex	N	SX	SY	SX^2	SY^2	SXY
Male	18	17.4548	18.8488	16.9653	20.3594	18.4296
Female	32	30.4641	31.9308	29.0374	32.3736	30.5231

N = Number of fish. SX, SY = Sum of logarithmic values of fork lengths and weights respectively. SX^2, SY^2, SXY = Sum of squares and products.

TABLE 43

REGRESSION DATA OF LENGTH-WEIGHT RELATIONSHIP OF MALES AND FEMALES*

Sex	D.F.	Sum of squares and products			b	Errors of Estimate	
		x^2	xy	y^2		D.F.	S.S.
Male	17	0.0392	0.1517	0.6218	3.87	16	0.0347
Female	31	0.0355	0.1249	0.5119	3.52	30	0.0725

*Notations are same as in table 11.

TABLE 44

TEST OF SIGNIFICANCE

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within sexes	46	0.1072	0.00233	1.0130	252
Differences between regressions	1	0.0023	0.0023		
Deviation from total regression	47	0.1095			

TABLE 45

VALUES OF 'n' FROM THANGACHIMADAM (BAG-NET CATCHES)

Months	Males	Females	Pooled data
May 1957	3.71	3.74	3.73
June	3.76	3.44	3.46
July	3.86	3.16	3.04
August	3.07	3.48	3.31
September	3.99	2.96	2.99
October	3.19	2.84	3.10
November 1957 to March 1958		No data	
April	3.21	3.49	3.36
VALUES OF 'n' FROM PUDUMADAM (SHORE-SEINE CATCHES)			
May 1957	3.87	3.52	3.66
June	--	3.62	--
July	--	--	--
August	3.37	3.81	3.55
September	--	--	--
October	2.70	2.78	2.88
November	3.32	3.53	3.40
December	3.24	3.58	3.43
January 1958	--	--	--
February	2.97	2.96	3.02
March	2.26	2.09	2.18

Hickling (1940) in his studies on herrings observed that in an advanced state of maturity the weight of the entire fish increases with length, at a rate much less than the cube of the length, and therefore the fish alone without the gonads and gut, must increase, with length at an even slower rate, nearer the square than the cube of the length.

In the light of Hickling's observations (op. cit.) it may be said that the least values of 'n' can be made use of to find out the spawning season or more precisely the advanced state of maturity of the fish which according to table 45 will be September-October and February-March.

Separate equations for immature, maturing, mature, spent** and gutted individuals were also calculated as described above and they were found to be as follows:

Immature: $W = 0.006540\ L^{3.3853}$

Maturing: $W = 0.08984\ L^{3.2066}$

Mature: $W = 0.07137\ L^{3.2943}$

Spent: $W = 0.05657\ L^{2.4237}$

Gutted: $W = 0.009317\ L^{3.1730}$

The length-weight values for different stages of maturity and gutted fish were then analysed by the method of Analysis of Covariance. Relevant details are given in tables 46 to 48.

TABLE 46

STATISTICS OF THE LENGTH-WEIGHT RELATIONSHIP OF IMMATURE, MATURING, MATURE, SPENT AND GUTTED FISH*

Character	N	SX	SY	SX^2	SY^2	SXY
Immature	70	59.4808	48.4476	50.7285	35.8894	41.7972
Maturing	50	51.2186	61.9152	52.5482	77.6207	63.6849
Mature	50	53.9731	70.4863	58.3217	100.1330	76.2843
Spent	50	51.9369	63.5071	53.9606	80.7577	65.9958
Gutted	70	73.0794	89.7304	76.4226	116.3636	94.0849

* Notations are same as in table 42.

** For the definition of stages of maturity refer to chapter 9.

TABLE 47

REGRESSION DATA OF LENGTH-WEIGHT RELATIONSHIP OF IMMATURE, MATURING, MATURE, SPENT AND GUTTED FISH*

Character	D.F.	Sum of squares and products			b	Errors of Estimate	
		x^2	xy	y^2		D.F.	S.S.
Immature	69	0.1861	0.6300	2.3584	3.3853	68	0.2257
Maturing	49	0.0813	0.2607	0.9509	3.2066	48	0.1149
Mature	49	0.0598	0.1970	0.7666	3.2943	48	0.1176
Spent	49	0.0118	0.0286	0.0947	2.4237	48	0.0254
Gutted	69	0.1283	0.4071	1.3415	3.1730	68	0.0498

* Notations are same as in table 11.

TABLE 48

TEST OF SIGNIFICANCE

Source of variation	Degrees of freedom	Sum of squares	Mean square	Observed F.	5%F.
Deviation from individual regressions within different stages of maturity and gutted fish	280	0.5334	0.0019	1.6316	2.39
Differences among regressions	4	0.0124	0.0031		
Deviation from total regression	284	0.5458			

It may thus be seen from table 48 that the length-weight relationship for different stages of maturity and gutted fish does not differ significantly. Hence a pooled equation for the entire data was calculated which gave the following value:

$$W = 0.01089\ L^{3.1182}$$

The logarithmic equation was found out to be $\log W = -1.9628+3.1182 \log L$.

The observed values for the corresponding lengths and weights are plotted in Plate 3, Fig.34 and show a close fit to the calculated values. The logarithmic values for lengths and weights are plotted in Plate 3, Fig.35 which gives a straight line relationship.

It can be inferred from Fig.34 that an increase in weight is more rapid from 8 cm. and above, therefore, it may be more economical from the commercial point of view to catch fish over 8 cm.

?

CHAPTER 9

REPRODUCTION

Sexes in <u>Selaroides leptolepis</u> are separate but the fish do not show any sexual dimorphism. When the fish are mature the males and females can be differentiated by applying a gentle pressure on either side of the abdomen when the milt or the ova, as the case may be, will ooze out.

The two ovaries lie in the posterior part of the abdomen, free at their anterior and posterior ends but united in the middle portion. The right ovary is slightly larger than the left. Ovaries are visible to the naked eye as small pin heads in the posterior region of the abdominal cavity and when fully ripe occupy the whole body cavity. It has not been possible to distinguish the sexes in specimens smaller than 6 cm., even in these specimens difficulties were experienced to identify the sex, without the aid of microscopic examination.

Classification of maturity stages.

The maturity stages given by the International Council for the Exploration of the Sea could not be adopted for the present study and therefore a different classification of the stages has been found necessary. The stages followed in this investigation are given below:

Stage I Ovaries small, pin head-like structures, flesh coloured. Eggs not visible to the naked eye.

Stage II Ovaries occupy ½ the body cavity, translucent, flesh coloured, ova visible to the naked eye, traces of yolk appear (includes spent-recovering also).

Stage III Ovaries occupy ¾ of the body cavity, opaque, with large partially yolk laiden ova. The ovaries have a tinge of yellow colour.

Stage IV Ovaries fully occupy the body cavity, eggs large, fully laiden with yolk, golden yellow in colour, a few ova may be semi-transparent.

Stage V Ovaries swollen, yolk almost transparent and eggs reach their maximum diameter, single oil globule present (spawners).

Stage VI Spent. Ovaries blood-shot, a few degenerating ova can be seen (Spent-recovering ovaries look like Stage II described above).

For the sake of convenience Stage I will be described, hereafter, as immature, Stages II and III as maturing, Stage IV as mature and Stage VI as spent. Stage V indicates spawners.

In males the testes first appear as slender, thread-like short structures to the naked eye. As maturity advances they become more prominent and when fully grown occupy the entire body cavity.

The ovaries from the fresh fish were either removed and preserved separately or preserved in situ in 5 per cent formalin. When they were sufficiently hardened, a small piece was taken and teased on a microslide. The ova were carefully separated with fine needles and as evenly as possible spread out on the slide. Due to the effect of preservation some of the ova were irregular in shape. The micrometer was adjusted in a horizontal position and the diameter of ova measured parallel to the gradations on the micrometer. This gave measurements of the longest diameters of some eggs, of the shortest of others or measurements between the two. Clark (1925, 1934), De Jong (1940) and Prabhu (1956) have found this method to give satisfactory results. De Jong (op. cit.) is of the opinion that as a consequence of following this method, in the frequency polygons of the diameters of ova, the differences between two groups of eggs appear less than they are in reality. He further says that in some cases the largest diameter of an egg of the group of the younger eggs exceeds the smallest diameter of an egg of the older group. Thus, in the consideration of different graphs, the fact has to be borne in mind that if two groups of eggs are apparently connected by a few ova of intermediate size, this connection as a rule, does not exist and both groups are clearly separated during life. The diameters of the eggs were measured under a compound microscope with an ocular micrometer at a magnification which gave a value of 19 microns to each micrometer division. It should be pointed out here, that an ovum which measured, say, more than 114 but less than 133 microns was treated in a higher group and so on. The measurements of ova from each fish were grouped into size intervals of 38 microns.

To find out whether the ova produced at the anterior, middle and posterior portions of the ovaries bear the same relationship to each other or not, measurements of ova taken from all these regions of Stage V ovaries were made. The results are presented in Plate 3, Fig. 36, which show that there are no significant differences either in their relative numbers or in the pattern. For the frequency polygons of this figure, ova more than 38 and less than 95 microns were also taken into consideration. But as it was ~~much~~ very time consuming to take the diameter of these small eggs, due to their large number, in the subsequent studies ova with diameter of 95 microns and above were taken. To ensure maximum accuracy, ova from the middle portion (where the two ovaries are united) were measured in all the stages.

In the immature ovaries (Stage I) the maximum ova diameter is 114 microns. Ovaries with ova diameter up to 190 microns are classified as Stage II. In Stage III the diameter ranges up to 304 microns and in Stage IV the maximum diameter is 494 microns. The ova of Stage V are well differentiated with a maximum diameter of 646 microns. In the ovaries of S. leptolepis such ova are sharply differentiated from the rest. Each ripe ovum is perfectly spherical with its almost transparent yolk and a slightly eccentrically placed oil globule of pink colour. The oil globule has a diameter varying from 152 to 171 microns. The perivitalline membrane is not formed at this stage. Such a stage was of extremely rare occurrence in the collections. During the course of this study only 3 individuals could be collected in spite of the intensive efforts made.

Seasonal progression of ova.

To determine the seasonal progression of ova, fish were studied in every month and the resulting percentage frequencies of ova are plotted in Plate 3, Fig.37. The samples for January show the presence of three groups of ova. The first group which consists of ova up to size of 114 microns are found as a dominant group throughout the year. This is the immature group of ova which would give rise to the eggs that would be spawned during the succeeding season. The second group with a mode at 304 microns is the maturing and the third with a maximum diameter of 494 microns is the mature group. From January onwards there is an increase in the relative number of ova although the maximum diameter remains more or less the same in February. In March there is a noticeable increase in size of ova and those of Stage V have separated from the rest of the stock. Before this group of ova is completely shed, another makes its appearance which will be spawned subsequently. This is clear from the polygons for the months of April and May. This shows that first spawning takes place in the months of February and March. In June, all the fish examined had mostly immature ova but the polygons for the month of July show an increase in the size of ova. In August maximum size of the ova is attained. This group of ova has a mode at 570 microns and is separated from the rest of the stock. Before this group is shed, another group has already made its appearance and this will be spawned in the next spawning season.

The graphs for the months of March and August, therefore, indicate that there are two spawning seasons and these are confirmed by the occurrence of juveniles and Stage IV twice a year.

<u>Size at first maturity.</u>

For determining the size at first maturity fish were examined during the months of July to September in 1957 and 1958, and again during January to March 1958 and 1959. The percentages of mature males and females at each half centimetre length interval were calculated and the resulting frequencies are plotted in Plate 3, Figs. 38 and 39 respectively. For males it was observed (Fig.38) that in the July to September 1957 samples, 17.4 per cent of the individuals reached first maturity in the group 9.1 to 9.5 cm., 23.1 in 9.6 to 10.0 cm., 52.6 in 10.1 to 10.5 cm. and 66.7 per cent in 10.6 to 11.0 cm. All the individuals above 11.0 cm. were mature. In the July to September 1958 samples, first sign of maturity in males appeared in the size 8.6 to 9.0 cm. when only 4.2 per cent were mature. Thereafter the percentage of the mature individuals increased. Examination of the samples in the months of January to March 1958 and 1959 revealed that mature individuals first appeared in 9.6 to 10.0 cm. and 10.1 to 10.5 cm. groups respectively. On the basis of four spawning seasons it may, thus, be concluded that first sign of maturity in males appear when the fish are about 8.7 cm.

Females were first noticed to mature in 8.6 to 9.0 cm. group in the samples of July to September 1957 when 4.7 per cent attained maturity (Fig. 39). 22.9 per cent of the females were mature in the group 9.1 to 9.5 cm., 46.3 in 9.6 to 10.0 cm., 60.0 in 10.1 to 10.5 cm. and 76.0 in 10.6 to 11.0 cm. Thereafter all the females were mature. In the July to September 1958 samples, size at first maturity in females was recorded in the group 9.1 to 9.5 cm.

Similarly, in the January to March 1958 and 1959 samples mature females were noticed in the group 9.6 to 10.0 cm., when 23.1 and 42.8 per cent of them respectively had attained maturity. It may, thus, be concluded from Fig.39 that females first start maturing when they are about 8.8 cm.

Besides the above method, the size at first maturity in females was also found out from the ova diameter studies during the spawning seasons. For this purpose, the biggest diameter of common eggs was taken into consideration. The females between 8.0 and 14.0 cm. were examined. Spent ovaries were excluded. The results are plotted as scatter diagrams in Plate 3, Figs.40 and 41. In Fig.40, three groups of ova can be made out — the first group lying between 38 ~~to~~ and 114 microns, second between 115 ~~to~~ and 304 and third above 304 microns. In this figure observations for 1957 and 1958 for the months of July, August and September are plotted. Most of the fish in July have ova falling in first and second groups, but a few ova of third group are also present. In August most of the fish fall in the third group and in September, with the exception of a few fish, all have ova more than 304 microns showing thereby that it is the month of intensive spawning. Observations for the months of January, February and March 1958 and 1959 are plotted in Fig.41, where more or less similar results as in figure 40 can be made out. Here the period of intensive spawning is

February. From Fig.40 it is inferred that a few fish mature between 8.8 to 9.0 cm., slightly more in 9.1 to 9.5 cm. and more than 50 per cent are mature from 10.1 cm. and above. Thus the size at first maturity may be said to be 8.8 cm. which is in agreement with the results arrived at independently ~~with~~ from the occurrence of mature individuals during the spawning seasons.

The size of 8.7 and 8.8 cm. in males and females respectively at the time of first maturity is attained when they are about 6 months old, as is inferred from the length-frequency studies (vide infra).

Spawning season.

Tables 49 to 52 indicate the occurrence of Stages I to VI from Thangachimadam, Rameswaram, Rameswaram Road and Pudumadam from May 1957 to May 1959 respectively. These figures relate to females only.

TABLE 49

PERCENTAGE OCCURRENCE OF MATURITY STAGES IN S. LEPTOLEPIS DURING DIFFERENT MONTHS AT THANGACHIMADAM*

Months and years	Stages						Total No. of specimens examined
	I	II	III	IV	V	VI	
May 1957	--	32.61 (15)	45.65 (21)	21.74 (10)	--	--	46
June	46.15 (24)	42.31 (22)	7.69 (4)	3.85 (2)	--	--	52
July	--	6.25 (1)	68.75 (11)	25.00 (4)	--	--	16
August	4.23 (3)	15.49 (11)	46.48 (33)	33.80 (24)	--	--	71

--**Continued**

Months and years	Stages I	II	III	IV	V	VI	Total No. of specimens examined
September 1957	--	16.16 (16)	30.30 (30)	53.54 (53)	--	--	99
October	2.70 (1)	21.62 (8)	43.24 (16)	32.43 (12)	--	--	37
November 1957 to February 1958			No data				
March	--	--	--	100.00 (9)	--	--	9
April	31.34 (21)	8.96 (6)	1.49 (1)	58.21 (39)	--	--	67
May	81.08 (60)	16.22 (12)	2.70 (2)	--	--	--	74
June	47.30 (35)	40.54 (30)	2.70 (2)	--	--	9.46 (7)	74
July	--	65.52 (19)	27.59 (8)	3.45 (1)	--	3.45 (1)	29
August	17.24 (5)	79.31 (23)	3.45 (1)	--	--	--	29
September	--	27.42 (17)	14.52 (9)	46.77 (29)	--	11.29 (7)	62
October	--	35.56 (16)	15.56 (7)	13.33 (6)	--	35.56 (16)	45
November	--	80.00 (4)	20.00 (1)	--	--	--	5
December 1958 to February 1959			No data				
March	1.49 (1)	--	35.82 (24)	52.24 (35)	--	10.45 (7)	67
April	33.33 (18)	7.41 (4)	18.52 (10)	37.04 (20)	--	3.70 (2)	54
May	30.00 (18)	48.34 (29)	18.33 (11)	--	--	3.33 (2)	60

* Figures in brackets are the number of specimens examined in each Stage.

TABLE 50

PERCENTAGE OCCURRENCE OF MATURITY STAGES IN *S. LEPTOLEPIS* DURING DIFFERENT MONTHS AT PUDUMADAM*

Months and years	Stages I	II	III	IV	V	VI	Total No. of specimens examined
May 1957	--	22.22 (14)	66.67 (42)	11.11 (7)	--	--	63
June	58.82 (10)	17.65 (3)	23.53 (4)	--	--	--	17
July	--	--	--	--	--	--	--
August	25.00 (1)	--	75.00 (3)	--	--	--	4
September	--	18.18 (2)	27.27 (3)	54.55 (6)	--	--	11
October	--	--	--	--	--	--	--
November	6.67 (1)	66.67 (10)	26.66 (4)	--	--	--	15
December	--	57.14 (4)	42.86 (3)	--	--	--	7
January 1958	--	75.00 (6)	--	25.00 (2)	--	--	8
February	--	4.92 (3)	3.28 (2)	91.80 (56)	--	--	61
March	--	35.40 (40)	--	50.44 (57)	--	14.16 (16)	113
April	--	3.45 (1)	--	--	--	96.55 (28)	29
May	--	--	--	--	--	100.00 (7)	7
June	67.06 (57)	24.71 (21)	--	--	--	8.24 (7)	85
July	22.62 (19)	76.19 (64)	--	1.19 (1)	--	--	84
August	--	8.16 (4)	57.14 (28)	26.53 (13)	6.12 (3)	2.04 (1)	49
September	--	--	--	100.00 (3)	--	--	3
October	--	--	--	--	--	--	--
November	35.29 (6)	58.82 (10)	5.88 (1)	--	--	--	17
December	--	86.05 (37)	--	13.95 (6)	--	--	43
January 1959	--	46.67 (7)	13.33 (2)	40.00 (6)	--	--	15

--<u>Continued</u>

Months and years	Stages I	II	III	IV	V	VI	Total No. of specimens examined
February 1959	--	--	18.45 (19)	57.28 (59)	--	24.27 (25)	103
March	--	7.02 (4)	33.33 (19)	15.79 (9)	--	43.86 (25)	57

* Figures in brackets are the number of specimens examined in each Stage.

TABLE 51

PERCENTAGE OCCURRENCE OF MATURITY STAGES IN <u>S. LEPTOLEPIS</u> DURING DIFFERENT MONTHS AT RAMESWARAM*

Months and years	Stages I	II	III	IV	V	VI	Total No. of specimens examined
June 1957	85.00 (34)	10.00 (4)	2.50 (1)	2.50 (1)	--	--	40
July	--	100.00 (53)	--	--	--	--	53
August	--	79.26 (107)	13.33 (18)	7.41 (10)	--	--	135
September 1957 to March 1958			No data				
April	97.14 (34)	2.86 (1)	--	--	--	--	35
May	86.00 (86)	11.00 (11)	1.00 (1)	--	--	2.00 (2)	100
June 1958 to August 1958			No data				
September	--	9.09 (1)	--	90.91 (10)	--	--	11
October	--	8.33 (1)	8.33 (1)	83.33 (10)	--	--	12
November 1958 to March 1959			No data				
April	72.73 (40)	18.18 (10)	1.82 (1)	--	--	7.27 (4)	55

* Figures in brackets are the number of specimens examined in each Stage.

TABLE 52

PERCENTAGE OCCURRENCE OF MATURITY STAGES IN S. LEPTOLEPIS DURING DIFFERENT MONTHS AT RAMESWARAM ROAD*

Months and years	Stages I	II	III	IV	V	VI	Total No. of specimens examined
December 1957	--	66.67 (2)	33.33 (1)	--	--	--	3
January 1958	--	--	--	--	--	--	--
February	--	--	2.27 (1)	97.73 (43)	--	--	44
March	--	--	--	100.00 (31)	--	--	31
April	--	11.76 (2)	--	--	--	88.24 (15)	17
May 1958 to November 1958			No data				
December	--	40.00 (6)	40.00 (6)	20.00 (3)	--	--	15
January 1959	--	--	--	--	--	--	--
February	--	--	29.31 (17)	43.10 (25)	--	27.59 (16)	58
March	--	11.11 (3)	25.93 (7)	37.04 (10)	--	25.93 (7)	27
April	7.69 (1)	46.15 (6)	--	--	--	46.15 (6)	13

* Figures in brackets are the number of specimens examined in each Stage.

From table 49 it can be seen that Stage IV occurred from May to October 1957 with a maximum of 53 per cent in September at Thangachimadam. In 1958 Stage IV was absent from the collections during the months of May, June and August. All females examined were mature in March, and 58.21 per cent in April. In September, there occurred both mature and spent individuals with a total percentage of 58.06. A comparison of this stage in September of these two years indicates that intensive spawning occurs during this month, although it might start in August and end in

October. The occurrence of mature individuals in March and April is again an index for their spawning. In 1959, high percentage of mature individuals was recorded again in March and April. Further, the occurrence of spent individuals during these months was also noticeable. The total percentage of mature and spent individuals in these months being 62.69 and 40.74 respectively. The appearance of the juveniles in April and May and sometimes in June is a further proof that the fish have spawned sometime during February-March. The results of March and April in 1958 and 1959 are in close agreement with each other as far as spawning periods are concerned.

Considering the data collected from Pudumadam (table 50) for 1957, Stage IV was recorded in May and September only, the percentage being very low in the former. In 1958, mature specimens started occurring from January with the peak in February. In March the total percentage of mature and spent individuals was 64.60 per cent. In April 96.55 per cent of the individuals were in spent condition and in May 100 per cent. The mature individuals appeared again in July but their percentage was low. In August, 26.53 per cent were mature and 6.12 per cent in the ripe stage, thus raising the total of mature and ripe individuals to 32.65 per cent. In September, when only 3 specimens were available for study, all were in the mature state. The occurrence of Stage IV individuals in August and September was similar in 1957 and 1958. By the end of 1958 mature individuals again started appearing and in January 1959, 40 per cent of them were in Stage IV. In February, individuals of this stage were maximum and when grouped with Stage VI, their frequency increased to 81.55 per cent. In March Stages IV and VI constituted 59.65 per cent. Comparing these months with those of 1958, we notice a similarity between the results leading to the conclusion that the fish spawn twice, once during January to March/April with peak in February and a second time during July/August to October with peak in September.

Data from Rameswaram and Rameswaram Road though available for a short period, are presented as such in tables 51 and 52 respectively. The high percentage of Stage I in June 1957, April, May 1958 and April 1959 and those of Stage IV in September and October 1958 from Rameswaram again favour the view that fish have two spawnings in a year. The observations from Rameswaram Road (table 52) indicate high percentage of Stage II in December 1957, December 1958 and April 1959; those of Stage IV in February and March 1958, and February and March 1959; and of Stage VI in April 1958 and April 1959, confirming thereby the two spawning seasons.

Apart from these studies, plankton collections were periodically examined for the occurrence of eggs and larvae. Various types of carangid eggs occur in the plankton of the Gulf of Mannar and the Palk Bay. These eggs are distinguished by the presence of segmented yolk, and a pigmented oil globule (Delsman, 1926). Since the larvae that hatched out could not be reared to an identifiable stage, it has not been possible to establish with certainty the egg of *S. leptolepis* in spite of all efforts made. However, the carangid eggs collected from the plankton of the Gulf of Mannar and the Palk Bay, which had close resemblence with the intra-ovarian eggs, were provisionally referred to those of *S. leptolepis* (?). These eggs were separated from other planktonic eggs by the above mentioned characters. The number of the eggs in each sample was counted every week and the figures for the whole month were computed. The results are presented in table 53. Number of the eggs for the Gulf of Mannar and the Palk Bay is given separately.

TABLE 53

NUMBER OF CARANGID EGGS FROM THE WEEKLY PLANKTON SAMPLES OF THE GULF OF MANNAR AND THE PALK BAY

Months and years		Number of eggs Gulf of Mannar	Palk Bay
June 1958	..	--	--
July	..	73	--
August	..	116	10
September	..	420	548
October	..	1039	228
November	..	--	145
December	..	225	--

--Continued

Months and years		Number of eggs Gulf of Mannar	Palk Bay
January 1959	..	420	--
February	..	434	--
March	..	1597	24
April	..	88	--
May	..	107	--

It may be seen from the above table that the maximum number of eggs in the Gulf of Mannar was recorded first in October and then in the following March. In the Palk Bay the maximum concentration was in September and some eggs were also noticed in March. A comparison of the figures of table 53 with the occurrence of Stage IV in S. leptolepis in the corresponding months gives something in general about the extent of the spawning season of this fish indicating thereby the biannual spawning.

Relation between the weight of the fish and the ovaries.

Ovaries were weighed from the specimens collected from Thangachimadam during March to October 1958 to find out their probable effect on the spawning season of the fish. The data for January, February, November and December were not available for analysis due to the absence of fishing at this centre.

The formula $W_o = AW^b$ was employed to find out the relationship between the weight of the ovaries and weight of fish, where W_o and W denote weights of ovaries and fish in mg. and gm. respectively, and A and b are two constants. The values of b for the different months are tabulated in table 54 and are presented graphically in Plate 3, Fig.42.

TABLE 54

'b' VALUES FROM DIFFERENT MONTHS AT THANGACHIMADAM DURING 1958

Months		'b'
March	..	1.0075
April	..	1.9616
May	..	2.3638
June	..	2.4168
July	..	2.4781
August	..	2.2194
September	..	1.9066
October	..	0.8809

The low values in March and October indicate the condition of the ovaries and this can be expected only when the fish are in the spent condition. Thus it may be inferred that the fish had spawned once prior to March and second time prior to October, confirming thereby the biannual spawning.

Fecundity.

The fecundity studies are essential for estimating the size of the spawning population of any species of fish. The number of individuals in a spawning population can be estimated if the following are known: 1) the total number of eggs produced per year by all females in the population, 2) the average number of eggs produced per year by each female in the population, and 3) the sex ratio in the population.

Hickling and Rutenberg (1936) have shown that in the herring the eggs destined to be spawned in the current season are ripened simultaneously, for there is, in an ovary in an advanced stage of ripeness, a very sharp separation in point of size between the active yolky eggs and the small yolkless ones. Farran (1938) found that all the ripening eggs in a herring ovary are of approximately equal size, and that the number of the eggs destined to ripen is fixed from the time that the storage of yolk has begun. In the herring, therefore, the large yolky eggs are the whole of the season's crop of eggs, and a count of them gives the absolute fecundity of the fish.

Franz (1910 a & b) on his studies on Pleuronectes platessa, Kisselvitch (1923) on Caspian herrings, and Clark (1934) on Sardina caerulea showed that the fecundity of a fish increases in proportion to the square of its length. Clark (op. cit.) observed that in the case of Pacific Sardine the fecundity increases at a rate 1.9868 to the length. Simpson (1951) on his studies on plaice pointed out that the number of eggs is related to the volume of the ovary and consequently to the cube of the length.

Fecundity in S. leptolepis was calculated from the mature females from Thangachimadam during September-October, and from Pudumadam during February-March. The ovaries were removed carefully and preserved in 5 per cent formalin till they were sufficiently hard. Some of the ovaries were also preserved in Gilson's fluid as described by Simpson (op. cit.). It was found that this fluid did not yield good results. Subsequently the ovaries were hardened in 5 per cent formalin and after removing excessive moisture they were weighed on a chemical balance. The weights were taken up to the nearest milligram. From the known weight of the ovaries, a portion was cut and weighed. The ova visible to the naked eye in this piece were counted by separating them with the help of fine needles. From the number of the ova in a piece total number of the ova were computed by multiplying them by the weight of the ovaries.

The fecundity was studied in relation to length of fish and weight of ovaries. The general parabolic equation of the form $F = AL^x$ was used for length, and $F = AW_o^x$ for weight of the ovaries, where F is the number of eggs in thousands, A is a constant and x an exponent showing the relation between F & L, and F & W_o; L is in mm. and W_o in mg.

The equations for Pudumadam and Thangachimadam are given below:

Pudumadam

$$F = 0.004496\ L^{3.1618}$$

$$F = 4.555\ W_o^{1.2476}$$

Thangachimadam

$$F = 0.02569\ L^{2.8265}$$

$$F = 67.63\ W_o^{1.0313}$$

Plate 3, Figs. 43 and 45 show the scatter diagrams from Pudumadam for number of ova against length of fish and weight of ovaries respectively. Similarly Plate 3, Figs.44 and 46 give the same relations from Thangachimadam. It may thus be seen from these figures that the observed values lie fairly close to the calculated values. It would thus be concluded that fecundity increases at a rate of 2.8265 in relation to length from the bag-net samples of Thangachimadam and at somewhat higher rate from the shore-seine samples of Pudumadam, which may be attributed to the gear selection and the time of the determination of fecundity. The fecundity data from Thangachimadam correspond to September-October 1957 whereas from Pudumadam the data were collected during February-March 1959.

The fecundity ranges from 6304 ova at 9.5 cm. to 37375 at 13.1 cm.

Discussion.

Hickling and Rutenberg (1936) published measurements of diameter of the eggs from the ripe ovaries of hake, haddock, Pilchard, herring and Lepidogaster and suggested that the frequency distributions of such ova may provide information as to the spawning habits of new or rare species of fish. On the lines suggested by these authors, De Jong (1940) worked out the spawning periodicities of 13 species from the Java Sea, including that of *Caranx leptolepis*. De Jong (*op. cit.*) stated that conditions in tropical seas make it rather probable that specimens which contain ripe ovaries will be found throughout the year, so that a periodicity in the individual may be obliterated in the species as a whole. He further stated that bulk of the individuals may spawn within a short and definite period, thus showing a definite periodicity. He remarks, "To investigate the spawning habits of the species, systematic observations for at least 12 months are necessary to enable us to form definite conclusions." On the basis of his observations carried out during February to May 1939, he concluded that *Caranx leptolepis* has a very definite spawning period and that the second batch of eggs which gets differentiated from the general egg stock before the first batch is spawned, is an indication that the spawning seasons follow closely. In other species of *Caranx*, viz., *C. crumenophthalmus*, *C. mate* and *C. malam*, he found one batch of maturing eggs and after the shedding of these eggs, ovaries resembled empty sacs. Thus the spawning in these species though strictly periodic is different from that of *Caranx leptolepis* in so far that the former spawn once a year and the latter twice.

In India, Karandikar and Palekar (1950) and Palekar and Karandikar (1952) were the first to work on the lines suggested by Hickling and Rutenberg (*op. cit.*) and followed by De Jong (*op. cit.*) and others. They worked out the spawning periodicities of *Polynemus tetradactylus* and *Thrissocles purva* respectively. Later, Prabhu (1956) followed this line and worked out the spawning periodicities of 9 species of fishes belonging to seven different families. He also examined *Caranx* (*Selaroides*) *leptolepis* during February from the Gulf of Mannar and concluded that the fish have a restricted spawning period. He commented, "There may be yet another spawning season as judged from the presence of ova in Stage II at modes c and b in which yolk formation has already commenced before the ripe eggs are shed." He, therefore, concluded that spawning occurs once in February-March and probably second time in July-August.

The results of the present studies confirm the biannual spawning as observed by De Jong (1940) and Prabhu (1956).

That ~~the~~ temperature is one of the controlling factors in the process of spawning in temperate and cold water species has been shown by earlier workers (Orton, 1920; Qasim, 1956). Qasim (*op. cit.*) stated that northern fishes in British waters must breed very early in the year because their young larvae would be killed by the summer temperature if they bred later. Moreover, the spawning season of the marine animals which have planktotrophic larvae, must be so regulated that the larvae hatching during the season have ample food to survive.

Prasad (1957) published his studies on the surface temperature of the Gulf of Mannar. He concluded that at the beginning of the year the temperature is low, it then rises and is maximum in April (29.8°C). In May it falls to 25.1°C and in July it again rises. Thereafter, the temperature goes up till October and declines in November and by December it almost reaches the level as that of January. The same author in 1958a described the behaviour of plankton and it appears that the plankton rises and falls with increase and decrease in the temperature. The richness of the local waters in plankton in the months of February to March/April and August to October probably results in the spawning of the fish.

Prabhu (1956) stated that females of Caranx (Selaroides) leptolepis attain a size of 13.9 cm. at first maturity. It is, however, not clear whether it is the total length or fork length. According to the present observations the size at first maturity is about 8.8 cm. (fork length). The total length of a specimen measuring 8.8 cm. is not more than 10.2 cm. and thus the size at first maturity recorded by Prabhu is much higher than that observed during the present studies. Prabhu (op. cit.) examined specimens in the month of February from Rameswaram Road. At this centre, individuals smaller than 10.5 cm. (total length) occur very seldom. It is, therefore, not surprising that he did not come across the smaller individuals with ripe gonads. It should be further made clear here that neither De Jong (1940) nor Prabhu (1956) could get a stage like the one shown in the graphs for the months of March and August (Plate 3, Fig.37).

CHAPTER 10

SEX RATIO

The studies on sex ratio are essential so as to know whether there exists a differential fishing or not.

Sex ratio of Selaroides leptolepis was studied from weekly samples of Thangachimadam, Pudumadam, Rameswaram and Rameswaram Road. The figures were then calculated for the whole month from each place and are given in tables 55 to 58.

TABLE 55

SEX RATIO OF S. LEPTOLEPIS FROM THANGACHIMADAM

Months and years		Males	Females	Indeterminates
May 1957	..	47	73	--
June	..	3	52	--
July	..	13	16	--
August	..	25	71	--
September	..	119	99	--
October	..	63	37	--
November 1957 to February 1958		No data		
March	..	21	9	--
April	..	50	67	25
May	..	42	74	28
June	..	43	74	18
July	..	13	29	--
August	..	24	29	8
September	..	70	62	2
October	..	52	45	--
November	..	3	5	--
December 1958 to February 1959		No data		
March	..	60	67	--
April	..	49	54	22
May	..	44	60	11
Total		741	923	114

TABLE 56

SEX RATIO OF S. LEPTOLEPIS FROM PUDUMADAM

Months and years		Males	Females	Indeterminates
May 1957	..	33	67	--
June	..	3	17	--
July	..	--	--	--
August	..	4	4	--
September	..	2	11	--
October	..	--	--	--
November	..	12	15	10
December	..	7	7	--
January 1958	..	12	8	--
February	..	64	61	--
March	..	122	113	--
April	..	21	29	--
May	..	8	7	--
June	..	26	85	33
July	..	47	84	3
August	..	21	49	--
September	..	6	3	--
October	..	--	--	--
November	..	17	17	41
December	..	42	43	3
January 1959	..	8	15	--
February	..	39	103	--
March	..	12	57	--
Total		506	795	90

TABLE 57

SEX RATIO OF S. LEPTOLEPIS FROM RAMESWARAM

Months and years		Males	Females	Indeterminates
May 1957	..	--	--	--
June	..	--	40	--
July	..	12	53	--
August	..	47	135	18
September 1957 to March 1958			No data	
April	..	11	35	4
May	..	25	100	87
June 1958 to August 1958			No data	
September	..	14	11	--
October	..	3	12	--
November 1958 to March 1959			No data	
April	..	45	55	--
Total		157	441	109

TABLE 58

SEX RATIO OF S. LEPTOLEPIS FROM RAMESWARAM ROAD

Months and years		Males	Females	Indeterminates
May 1957 to November 1957			No data	
December	..	5	3	--
January 1958	..	--	--	--
February	..	26	44	--
March	..	19	31	--
April	..	8	17	--
May 1958 to November 1958			No data	
December	..	35	15	--
January 1959	..	3	1	--
February	..	110	58	--
March	..	27	27	--
April	..	12	13	--
Total		245	209	

A reference to these tables will indicate the occurrence of more females than males in almost all the months. Considering the data given in table 55 for Thangachimadam, it will be found that during the spawning season the difference between the two sexes is much less. For instance in September 1957, which is the month of intensive spawning, the ratio of males to females is 1.2:1. A similar case can be noticed in September 1958 when their ratio is 1.1:1. Again in April 1958 and 1959 there is very little difference in the proportion of males and females in the catch, showing thereby that during the spawning season, they occur in almost equal numbers. This condition, however, does not exist in other months. In certain collections, sometimes the entire sample consisted of either males or females.

To get a more correct picture the data for the entire period have been pooled and the ratio calculated. It was found that for 1 male there were 1.25 females.

In table 56 data for Pudumadam are given. When the samples were large, especially during the spawning season of 1958 (February to April), the differences in the sex ratio are very small. Immediately after this season the differences become more pronounced. In the same months in 1959, the position is changed. There are more females than males. The figures for the entire period when put together gave a ratio of 1 male : 1.57 females.

Figures for Rameswaram are given in table 57. Except for September 1958 and April 1959, male to female ratio is very high. In the total, the ratio was 1 male : 2.81 females, a ratio much higher than that observed either at Thangachimadam or Pudumadam.

At Rameswaram Road (table 58) the ratio for the entire period was 1.17 males : 1 female. More males were observed in February 1959 than females. This appears to be a solitary case when during the spawning season more males were caught than the females.

Month-wise figures from the four places pooled together are given in table 59.

TABLE 59

SEX RATIO OF S. LEPTOLEPIS FOR THE POOLED DATA OF THANGACHIMADAM, PUDUMADAM, RAMESWARAM ROAD AND RAMESWARAM

Months and years		Males	Females	Indeterminates
May 1957	..	80	140	--
June	..	6	109	--
July	..	25	69	--
August	..	76	210	18
September	..	121	110	--
October	..	63	37	--
November	..	12	15	10
December	..	12	10	--
January 1958	..	12	8	--
February	..	90	105	--
March	..	162	153	--
April	..	90	148	29
May	..	75	181	115
June	..	69	159	51
July	..	60	113	3
August	..	45	78	8
September	..	90	76	2
October	..	55	57	--
November	..	20	22	41
December	..	77	58	3
January 1959	..	11	16	--
February	..	149	161	--
March	..	99	151	--
April	..	106	122	22
May	..	44	60	11
Total		1645	2372	313

Table 59 gives a very clear picture of the distribution of the two sexes in the commercial catches. It shows that during September 1957, February to March and September to October 1958, and February to April 1959, the two sexes are almost in equal numbers. The variation in their ratio occurs before and after ~~thr~~ese months. Thus, there appears to be no differential fishing at least during the spawning period. Before and after that period more females are caught and when the total for the entire period from the four places was calculated, the ratio appeared to be 1 male : 1.44 females. During the course of this study 4330 individuals were examined, of which 1645 were males, 2372 females and 313 indeterminates.

It may thus be inferred from the above results that males and females appear to congregate during the spawning season and after it is over, they segregate. This may explain nearly 1:1 ratio during the spawning season which is equal to the theoretical ratio 1:1. However, the reasons for the slight changes in the sex ratio during the spawning seasons noticed at different centres are not known at present.

CHAPTER 11

AGE AND GROWTH

Studies on the age and growth of fish are very important from the point of view of fisheries research and already a considerable amount of information relating to various species, particularly European species, is available in literature. The papers of Graham (1929 a & b, 1956), Van Oosten (1929), Dannevig (1933), Hickling (1933), Johnston (1938), Le Cren (1947) and Allen (1956), Hornell and Nayudu (1923), Devanesan (1943), Nair (1949), Menon (1950, 1952), Seshappa (1958), Seshappa and Bhimachar (1951), Jhingran (1957), Sarojini (1957, 1958) and Pillay (1958) are only a few among the publications on this aspect. Structures such as scales, otoliths, vertebrae, fin rays, pectoral girdles, supraoccipital crests and opercular bones have been used by different workers in various fishes for assessing the age and growth. Petersen's method of length-frequency analysis is also widely used by most of the fishery workers.

Chugunov (1926), Graham (1929 a & b), Van Oosten (1929) and Menon (1950, 1952) gave detailed accounts on age determination of fishes by the use of scales, otoliths or bones.

In India, relatively little work has been done on the growth and age of fishes using the structures like the scales, otoliths and bones. Hornell and Nayudu (1923) were the first to notice growth rings on the scales of Indian Oil sardine, Sardinella longiceps, and they interpreted these rings as "Summer" and "Winter" rings. These rings, according to them, are formed when the growth ceases with the scarcity of planktonic food. Devanesan (1943) supported this view. Nair (1949) in his studies on the otoliths of the same species, also described the formation of rings due to scarcity of planktonic food and observed that the longevity is limited to 2½ years. Gopinath (1951) described the presence of concentric growth zones on the supra occipital crest of Caranx sexfasciatus. Seshappa and Bhimachar (1951) described certain rings in the Malabar sole, Cynoglossus semifasciatus Day, as the monsoon rings. Jhingran (1957) described the presence of annuli on the scales of Cirrhina mrigala. Seshappa (1958) gave an account of the occurrence of certain rings on the scales of Rastrelliger canagurta.

In order to see if any of the hard structures can be used for age and growth determination in Selaroides leptolepis an examination of scales, otoliths, opercular bones, and supra occipital crests was made.

Scales.

Scales are cycloid, thin but conspicuous and this justifies the name leptolepis (leptos = thin or slender, and *lepis* = scale). The scales on the posterior part of the lateral line are modified into scutes which are feeble as compared to many of the species of *Caranx* in which they form a bony spinous caudal keel.

Scales were examined from various parts of the body. A preliminary examination of them revealed that those from the pectoral axilla had clear ring like structures on them, whereas those studied from other parts of the body showed less clarity in them. Hence in the subsequent studies scales from the pectoral axilla were examined. The fish measuring more than 7 cm. were taken into consideration, as those smaller than this length had very small scales difficult to read. The scales were removed with a needle and washed in fresh water, mounted between two slides and examined under a microscope. Examination of the scales, from fish of different lengths, revealed the presence of certain rings which increase in number as the length increases. But, when fish of almost the same length were examined, the number of the rings was not constant. These rings, thus, could not be considered as regular growth checks and it was, therefore, not possible to come to any conclusion. Photograph 6 is of a scale from a fish measuring 11.9 cm. which shows number of rings on it. The formation of these rings may be attributed to several factors such as spawning, scarcity of food, changes in temperature and salinity as the case may be. However, on the basis of the data available at present, it has not been possible to attribute any one of these causes to the formation of the rings noticed in the scales.

Chugunov (1926) found that treating the bones with picrocarmine yielded good results. This method was also tried for scales. Scales were first washed in fresh water and then stained in 1 per cent solution of picrocarmine for 3 to 4 hours. These scales also on examination did not yield better results.

Supra occipital crests.

Supra occipital crests were collected from the fresh specimens. The heads of such fish were cut with a sharp scalpel and numbered. They were placed in hot water and after sometime skin and flesh were removed. Each crest was pulled up either by fingers or by a forceps.

Each crest was dried and studied under a stereoscopic microscope and was also projected on a wall in a dark room by using a prism projector. The fish more than 7 cm. were examined as in the case of scales. In Photograph 7 two crests are photographed at the same magnification; the upper one is from a specimen measuring 7.5 cm. and the lower from 13.0 cm. A careful examination of these crests will show the presence of dark and white bands alternating with each other. Counts of the dark bands indicate that there are at least four distinct and a few inconspicuous ones in each crest. The cause of the formation of these bands may be the same as that of the rings on the scales. However, the occurrence of almost the same number of bands on two crests of widely different lengths, together with the results of the present study do not throw any light as to their formation. Thus, these bands do not appear to be regular growth checks.

Crests stained in 1 per cent picrocarmine solution and examined in a similar way also did not yield better results.

Otoliths and other hard parts.

Otoliths were removed by giving a sharp deep cut along the supra occipital crest with a scalpel.

Unground otoliths were observed in creosote oil (Johnston, 1938) but rings were not noticed. They were ground against a carborandum (convex surface only) and then examined under a binocular microscope using reflected light. Rings could not be made out.

The examination of the preopercular bones and vertebrae for possible growth rings, also did not give any indic ation of such rings.

In the absence of any reliable result from the hard parts, data collected during this investigation on length-frequencies alone will have to be depended upon for the study of age and growth.

Length-frequency distributions.

Data collected from May 1957 to May 1959 are presented in the accompanying histograms. Shore-seine and bag-net samples have been treated separately. Plate 4, Fig.47 shows the histograms for the shore-seine samples and Plate 5, Fig.48 for the bag-net samples. Fish were grouped at half centimetre length-intervals and the figures given at the bottom of the histograms are the mid points for each half centimetre group.

Analysis of shore-seine samples: Beginning with May 1957 we notice two modes one at 9.3 and the other at 11.8 cm. The first mode at 9.3 cm. remains steady in June and is lost in July. In August there are some indications of it at 10.3 cm. and thereafter it is not traceable until in December when it appears at 13.3 cm. In January 1958 it remains at 13.3cm. and in February two modes at 13.3 and 14.8 cm. are marked. These modes are perhaps the continuation of the January 1958 mode. The fate of this mode in the subsequent months is not known. The mode at 9.3 cm. in May 1957 is the brood which appears for the first time in August/ September 1956.

The second mode at 11.8 cm. in May 1957 belongs to February/March 1956 and is not traceable in the successive months.

In June 1957 a new group with mode at 6.8 cm. enters the fishery and is traceable in the successive months at 7.3 cm. in July, 8.3 cm. in August and 9.8 cm. in September. Due to the absence of samples in October, nothing is known about this mode, but appears in November at 9.3 cm., slightly shifted backwards. In December the modes at 10.3 and 11.3 cm. are probably the continuation of the same mode and in January 1958 it appears at 11.3 cm. It is traceable in February at 11.8 cm. and is not represented in the samples of March and April. In May there is an indication of the mode at 12.3 cm. Thus, the fish which entered the fishery with a modal size of 6.8 cm. in June are the brood of February/March 1957 spawning and has attained a size of 12.3 cm. in one year.

In September 1957, another group is recruited to the fishery with the modal size of 7.8 cm. In November it is slightly shifted backwards and appears at 7.3 cm. and is absent in the December samples. In January 1958 it appears at 9.8 cm. and attains a modal size of 10.8 cm. in February.

It remains steady in March, April and May. In June it is at 11.3 cm. and remains so till August, thereafter this mode is not represented in the samples.

In April 1958 fish are again recruited, the first mode appears at 7.3 cm. In May it is at 6.3 cm. and attains a size of 7.3 cm. in June, 8.3 in July, 10.3 in August and September, and 10.8 cm. in November. In December the same group attains a size of 12.3 cm. and is represented at 12.8 cm. in January 1959. It remains steady till March.

The occurrence of juveniles in November 1958 marks another spawning which must have occurred in August to October. The first mode appears at 8.3 cm. in November and is traceable in successive months at 8.8 in December, 9.8 in January 1959, and 11.3 cm. in February, March and April. The occurrence of juveniles in April 1959 indicates a new spawning.

A closer examination of the histograms indicates that the fish grows rapidly in the first six months before the first spawning occurs. During the spawning season the growth is steady and immediately after spawning, it is prominent. The occurrence of juveniles twice in a year, thus, indicates biannual spawning of fish. The growth curves for the different broods traceable from the histograms are plotted in Plate 5, Fig.49.

Analysis of bag-net samples: Due to the absence of fishing in the Palk Bay from November to March, the data were not available during these months from Thangachimadam. However, the results of analysis are in fair agreement with the shore-seine samples.

In 1957, juveniles are first recorded in June with a mode at 6.8 cm. In the successive months this mode appears at 7.8 in July, 8.8 in August and 9.8 cm. in September and remains steady in October. Due to the absence of fishing nothing is known about this mode in the next months. This group is presumably the brood of February/March 1957 spawning.

The mode at 9.3 cm. in May 1957 remains steady in June and it attains a modal size of 9.8 cm. in July and August. In September and October samples it is not represented.

In March 1958 a prominent mode appears at 10.3 cm. and represents the September 1957 spawning. This mode remains more or less steady till June and attains a size of 10.8 cm. in July. In August it is at 11.3 cm. and 12.8 cm. in September, shifting to 12.3 cm. in October. It is thus fairly clear that in a year it (this group) has attained a size of 12.3 cm.

The appearance of juveniles in April 1958 indicates a new spawning. The mode at 7.3 cm. in April can be traced at 8.3 in May, 8.8 in June, 9.3 in July and August, and 10.3 cm. in September and October. Nothing is known about this mode in the following months due to the absence of fishing.

In April 1959, the three modes appearing at 6.8, 9.3 and 11.3 cm. represent three different broods as of February/March 1959, August/September 1958 and February/March 1958 respectively.

The shore-seine and bag-net samples, thus, indicate biannual spawning of the fish and also that the life span of the fish possibly is not more than two years; the growth is more before the first spawning, and there are indications of retardation of growth during the spawning season.

SUMMARY

The account deals with the biology and fishery of Selaroides leptolepis, locally known as "choo parai", one of the common carangids occurring in the Gulf of Mannar and the Palk Bay.

Material was collected from Thangachimadam and Rameswaram on the Palk Bay, and Rameswaram Road and Pudumadam on the Gulf of Mannar. Fishing is carried out at depths varying from 10 to 15 metres. Bag-nets, operated from catamarans, are used for fishing at Thangachimadam, and shore-seines at other centres. The fishing operations last from November to March in the Gulf of Mannar and April to October in the Palk Bay due to the North-East and South-West monsoons respectively.

Selaroides is treated as a genus and its taxonomic position is described. Variations in the meristic counts of dorsal and anal fin rays are described along with the descriptions given by other authors. The range of variations in the present work was noticed as I/21-27 dorsal rays and I/18-23 anal rays. Synonyms and world distribution are also dealt with.

Fishing methods, used for the fishery of S. leptolepis in the vicinity of Mandapam, are described. Juveniles of

fish were observed moving under the umbrella of jelly fishes. S. leptolepis occurs throughout the year and forms a good fishery in the months of February to May and August to October. Besides S. leptolepis, Caranx melampygus was the most common carangid in January and March. Other carangids like Carangoides oblongus, C. armatus, Caranx sexfasciatus, Selar mate, S. kalla, S. malam, Alectis ciliaris and A. indica were also observed in the catches. Monthly figures of carangids from May 1957 to April 1959 from different centres are given and their percentages in the total catch are calculated. In a tabulated statement, the percentage of carangids in the total catch in India from 1950 to 1958, is given and it was found that on an average they formed 2.6 per cent of the total catch during that period. S. leptolepis is generally consumed in the fresh state and whenever the quantities landed are heavy, the catch is sun-dried. Surplus quantities of big carangids are gutted, salted, dried and exported to Ceylon.

Population studies based on a statistical study of some of the morphometric and meristic characters of samples collected during 1957, 1958 and 1959 revealed the existence of certain distinct populations.

Investigations on the food and feeding habits of the fish

fish revealed that Acartia, Oithona, Euterpina, Decapod and molluscan larvae are favourite food items in the lower size groups, whereas Lucifer, Acetes, Mysids and fishes form the main food of fish in the higher ones. It is mainly a carnivore occasionally feeding on phytoplankton. The results also indicate that the fish do not feed at night.

Parasites of the genera Contracaecum and Cucullanus were recorded from the ovaries of the fish. They were more common during the spawning season than at any other time.

Length-weight relationship of the fish was determined by the general parabolic formula $W = cL^n$. Separate values of 'n' for males and females and for the pooled data are presented month-wise from May 1957 to April 1958. Analysis of the data for males, females, different stages of maturity and gutted fish showed non-significant differences. Hence a pooled equation for the entire data was calculated, where $W = 0.01089\ L^{3.1182}$.

Studies on the maturation and growth of the ova indicated two spawnings in a year, the first occurring in February/March and the second in August/September. On the basis of the occurrence of mature individuals in different months, spawning seasons were found to be January to March and July/August to October. The occurrence of carangid eggs in the plankton of the Gulf of Mannar and the Palk Bay helps to support, to some extent, the view that fish spawn twice a year. Further, the relation between the weight of the fish and weight of the ovaries also indicate the biannual spawning of the fish. It was found that females and males show first sign of maturity at 8.8 and 8.7 cm. respectively. The fecundity ranges from 6304 ova at 9.5 cm. to 37375 at 13.1 cm. The relations between the length of the fish and fecundity and weight of the ovaries and fecundity are described from the Thangachimadam and the Pudumadam samples.

It was not possible to establish the identity of a fertilized egg of S. leptolepis. Attempts to collect the running males and females proved futile, thus, artificial fertilization could not be tried.

Sex ratio was calculated for every month from different places. Males and females appear to congregate during the spawning season and after it is over they segregate. In other months, females were more common than males. Some samples, however, consisted exclusively of either males or females.

Scales and supra-occipital crests show rings and bands respectively but as their number was not constant they could not be considered as regular growth checks and hence could not be used in the determination of age and growth of the fish. Otoliths, preopercular bones and vertebrae did not show any marking which might help in assessing the age and growth of the fish. In the absence of reliable growth checks in the hard parts, length-frequency studies had to be depended upon for the study of age and growth. These studies show that the fish grows fast during the first six months i.e. before the first spawning, and there are indications of retardation of growth during the spawning season. The life span of the fish is possibly not more than two years.

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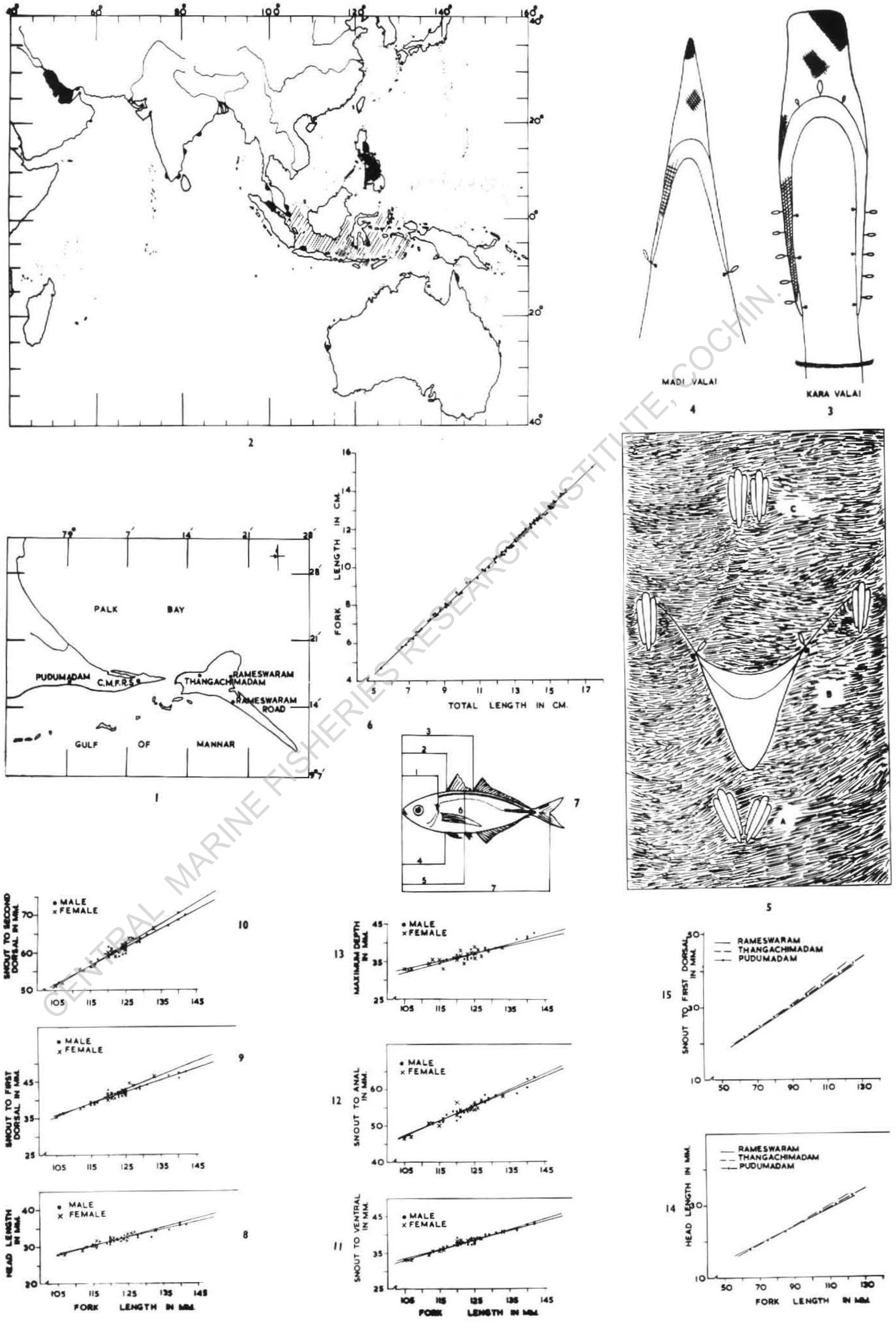
* Not consulted in original.

EXPLANATION OF PLATES

PLATE 1

PLATE I



PALK BAY
PUDUMADAM
C.M.F.R.S.
THANGACHIMADAM
RAMESWARAM
RAMESWARAM ROAD
GULF OF MANNAR
1
2
MADI VALAI
KARA VALAI
4
3
FORK LENGTH IN CM.
TOTAL LENGTH IN CM.
6
7
5
A
B
C
MALE
FEMALE
SNOUT TO SECOND DORSAL IN MM.
10
SNOUT TO FIRST DORSAL IN MM.
9
HEAD LENGTH IN MM.
8
FORK LENGTH IN MM.
MAXIMUM DEPTH IN MM.
13
SNOUT TO ANAL IN MM.
12
SNOUT TO VENTRAL IN MM.
11
RAMESWARAM
THANGACHIMADAM
PUDUMADAM
SNOUT TO FIRST DORSAL IN MM.
15
HEAD LENGTH IN MM.
14

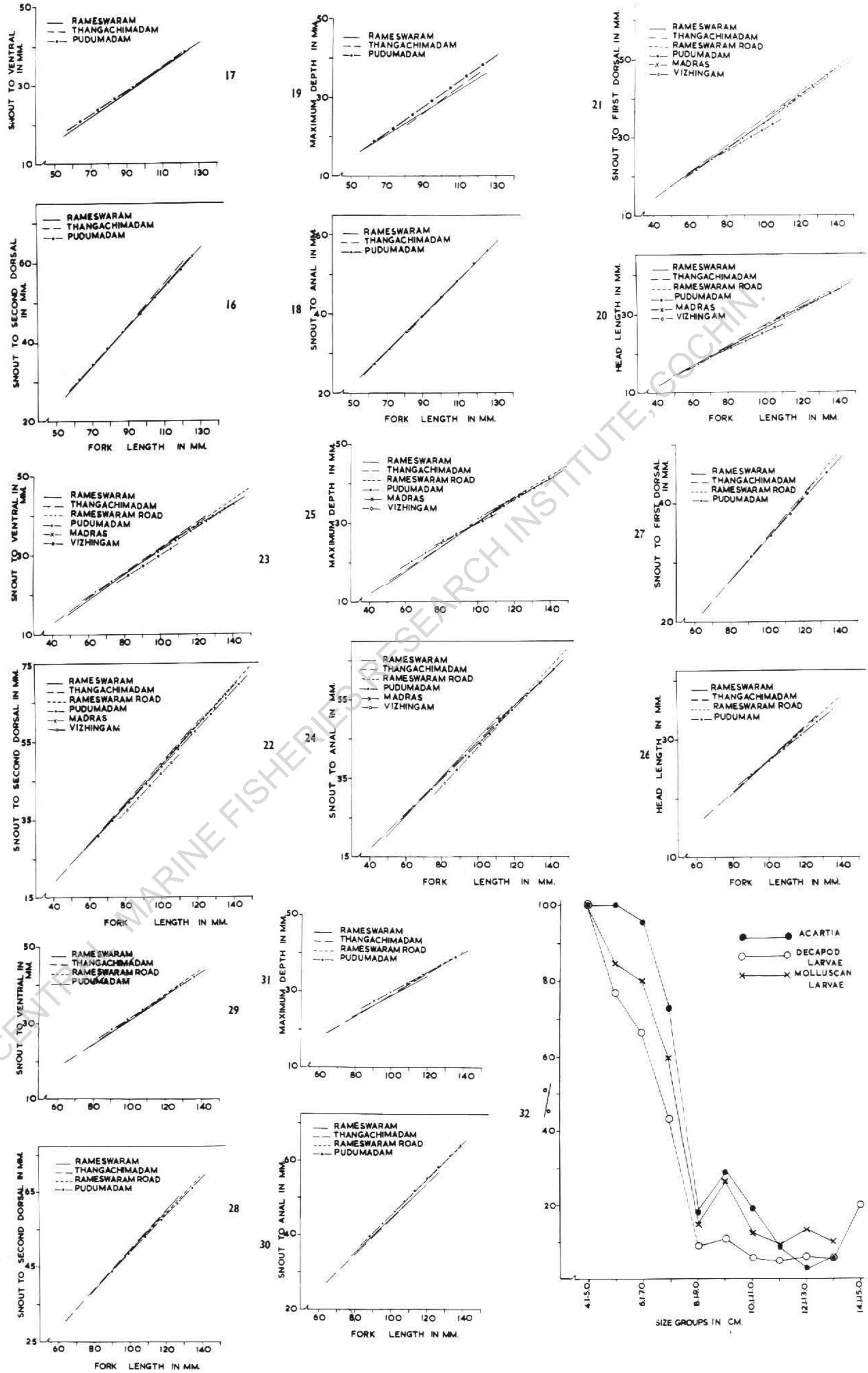
Figs.16 to 19. Regressions of snout to second dorsal, snout to ventral, snout to anal and maximum depth of body respectively on fork length from different centres during 1957.

Figs.20 to 25. Regressions of head length, snout to first dorsal, snout to second dorsal, snout to ventral, snout to anal and maximum depth of body respectively on fork length from different centres during 1958.

Figs.26 to 31. Regressions of head length, snout to first dorsal, snout to second dorsal, snout to ventral, snout to anal and maximum depth of body respectively on fork length from different centres during 1959.

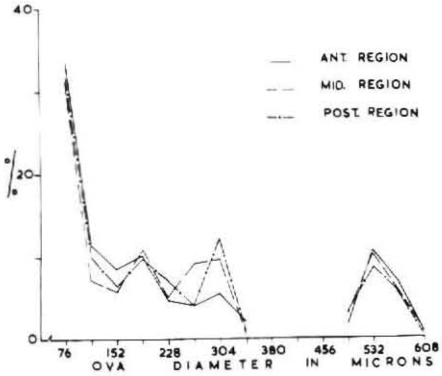
Fig.32. Relative importance of food items in different size groups.

PLATE 2



RAMESWARAM
THANGACHIMADAM
RAMESWARAM ROAD
PUDUMADAM
MADRAS
VIZHINGAM
SNOUT TO VENTRAL IN MM.
MAXIMUM DEPTH IN MM.
SNOUT TO FIRST DORSAL IN MM.
SNOUT TO SECOND DORSAL IN MM.
SNOUT TO ANAL IN MM.
HEAD LENGTH IN MM.
FORK LENGTH IN MM.
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
ACARTIA
DECAPOD LARVAE
MOLLUSCAN LARVAE
%
SIZE GROUPS IN CM.
4.1-5.0
6.1-7.0
8.1-9.0
10.1-11.0
12.1-13.0
14.1-15.0

PLATE 3



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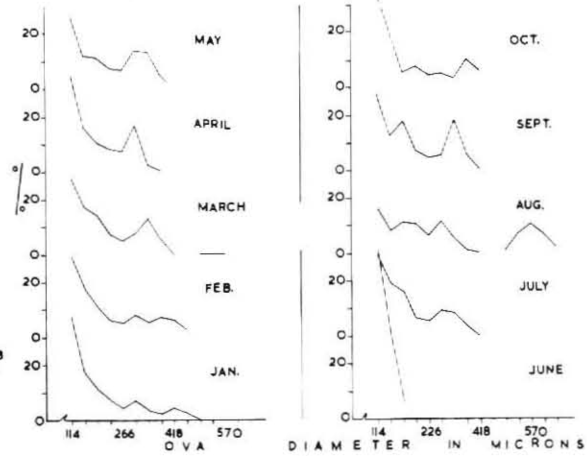

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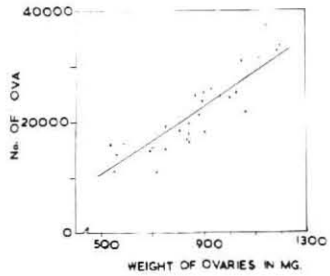

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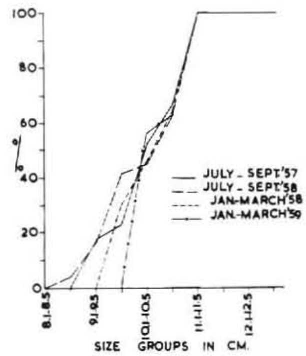

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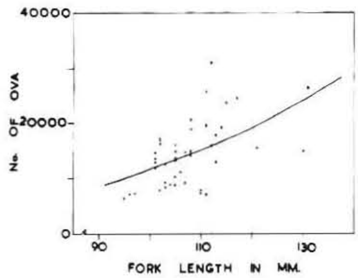

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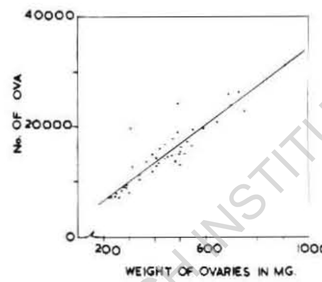

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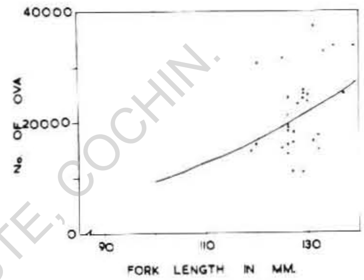

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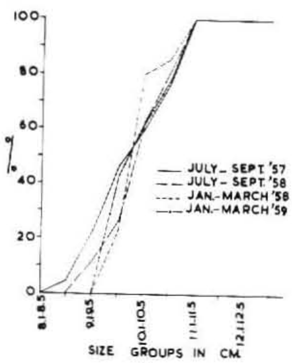

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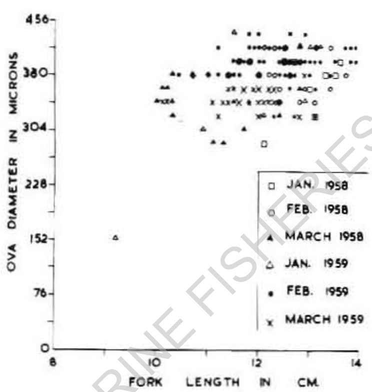

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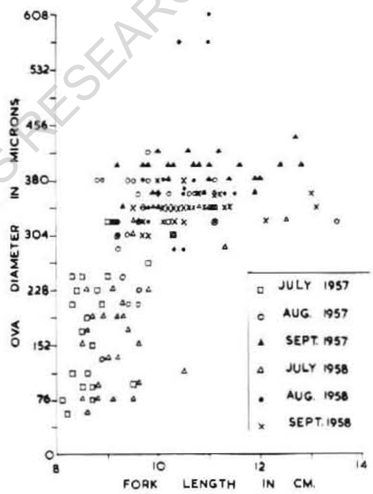

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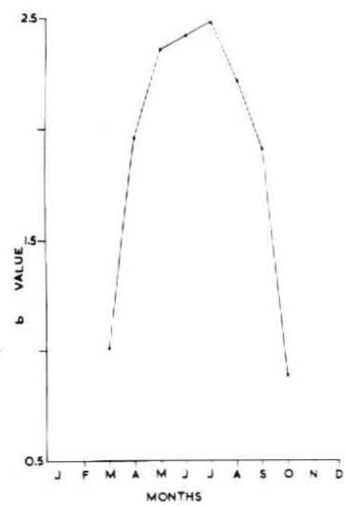

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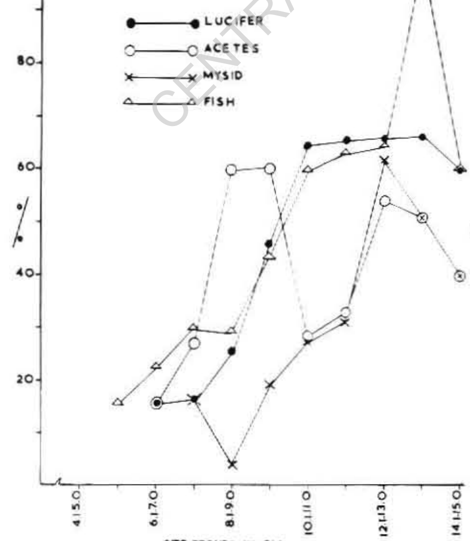

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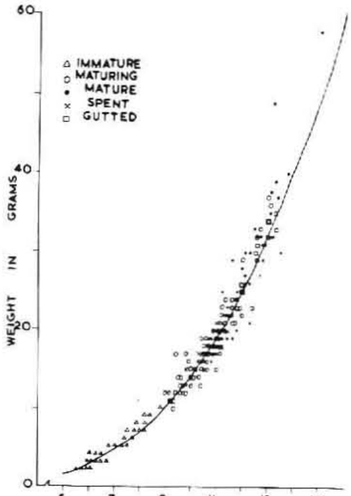

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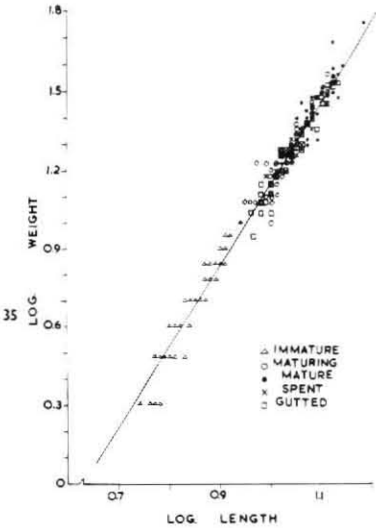
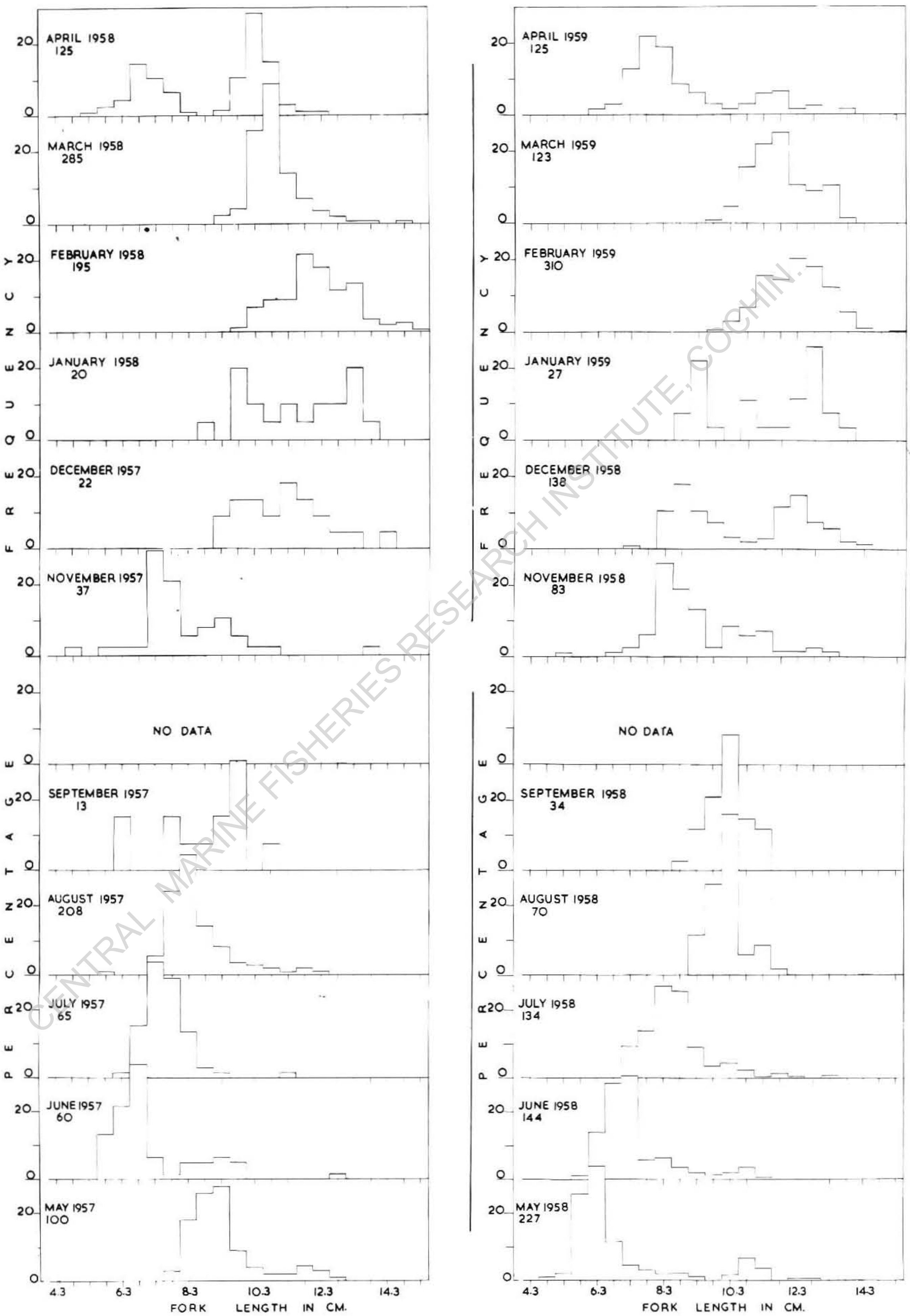


Fig.47. Length-frequency distributions of *Selaroides leptolepis* from the shore-seine catches. Number given below each month indicates the number of fish examined.

PLATE 4

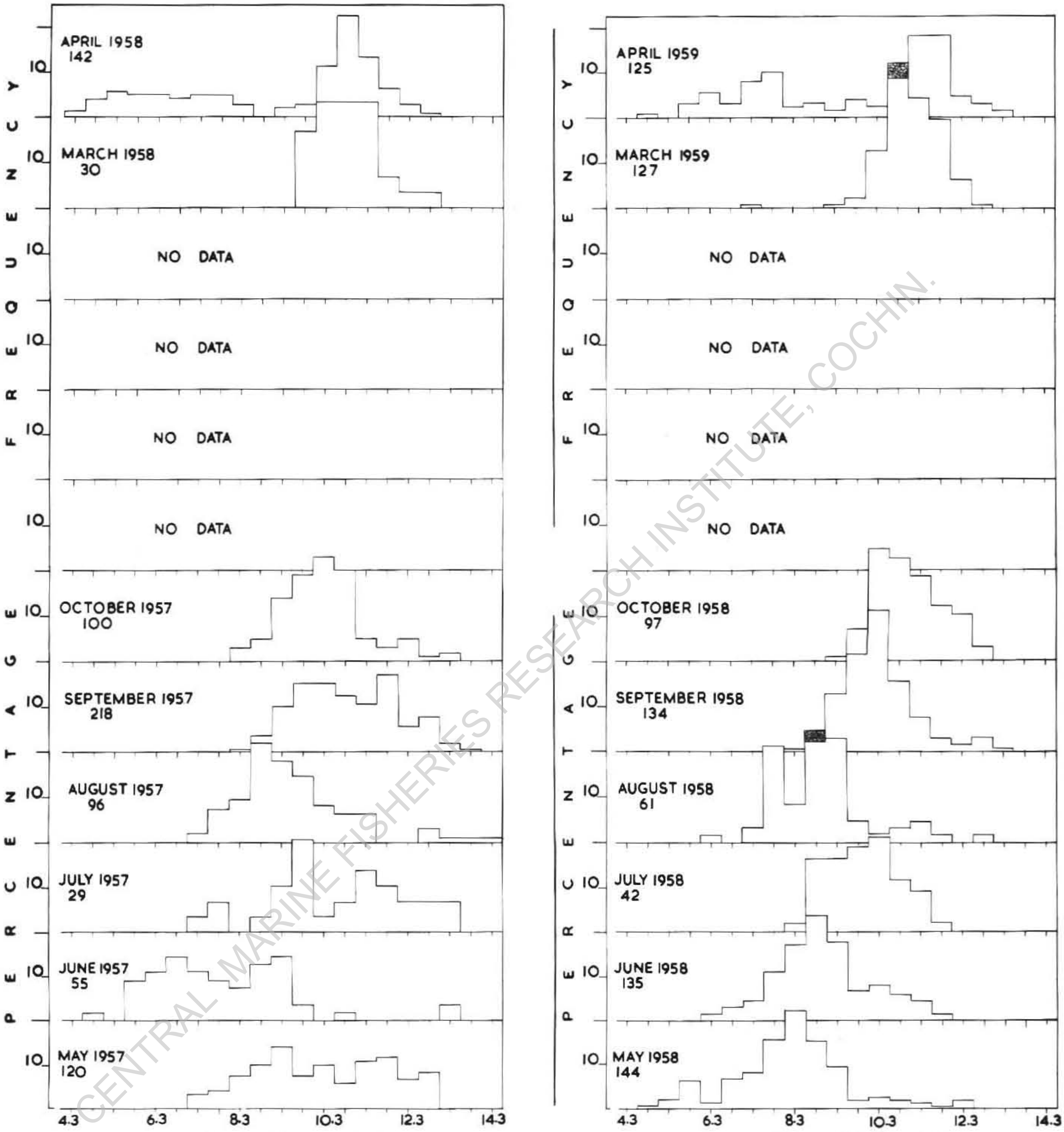


APRIL 1958
125
MARCH 1958
285
FEBRUARY 1958
195
JANUARY 1958
20
DECEMBER 1957
22
NOVEMBER 1957
37
NO DATA
SEPTEMBER 1957
13
AUGUST 1957
208
JULY 1957
65
JUNE 1957
60
MAY 1957
100
APRIL 1959
125
MARCH 1959
123
FEBRUARY 1959
310
JANUARY 1959
27
DECEMBER 1958
138
NOVEMBER 1958
83
NO DATA
SEPTEMBER 1958
34
AUGUST 1958
70
JULY 1958
134
JUNE 1958
144
MAY 1958
227
FREQUENCY
PERCENTAGE
0
20
4.3
6.3
8.3
10.3
12.3
14.3
FORK LENGTH IN CM.

Fig.48. Length-frequency distributions of <u>Selaroides leptolepis</u> from the bag-net catches. Number given below each month indicates the number of fish examined.

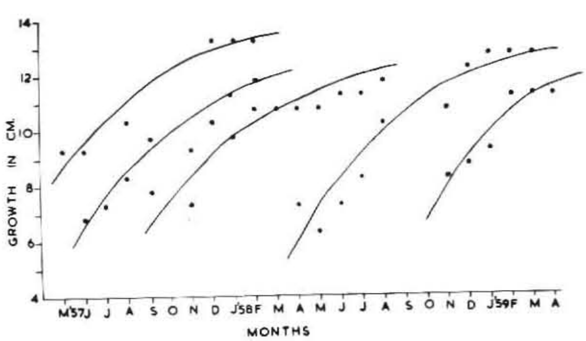
Fig.49. Growth curves as drawn from the shore-seine catches.

PLATE 5



FREQUENCY
PERCENTAGE
APRIL 1958
142
MARCH 1958
30
NO DATA
NO DATA
NO DATA
NO DATA
OCTOBER 1957
100
SEPTEMBER 1957
218
AUGUST 1957
96
JULY 1957
29
JUNE 1957
55
MAY 1957
120
APRIL 1959
125
MARCH 1959
127
NO DATA
NO DATA
NO DATA
NO DATA
OCTOBER 1958
97
SEPTEMBER 1958
134
AUGUST 1958
61
JULY 1958
42
JUNE 1958
135
MAY 1958
144
10
4.3
6.3
8.3
10.3
12.3
14.3
FORK LENGTH IN CM.

48



GROWTH IN CM.
4
6
8
10
12
14
M57J J A S O N D J58F M A M J J A S O N D J59F M A
MONTHS

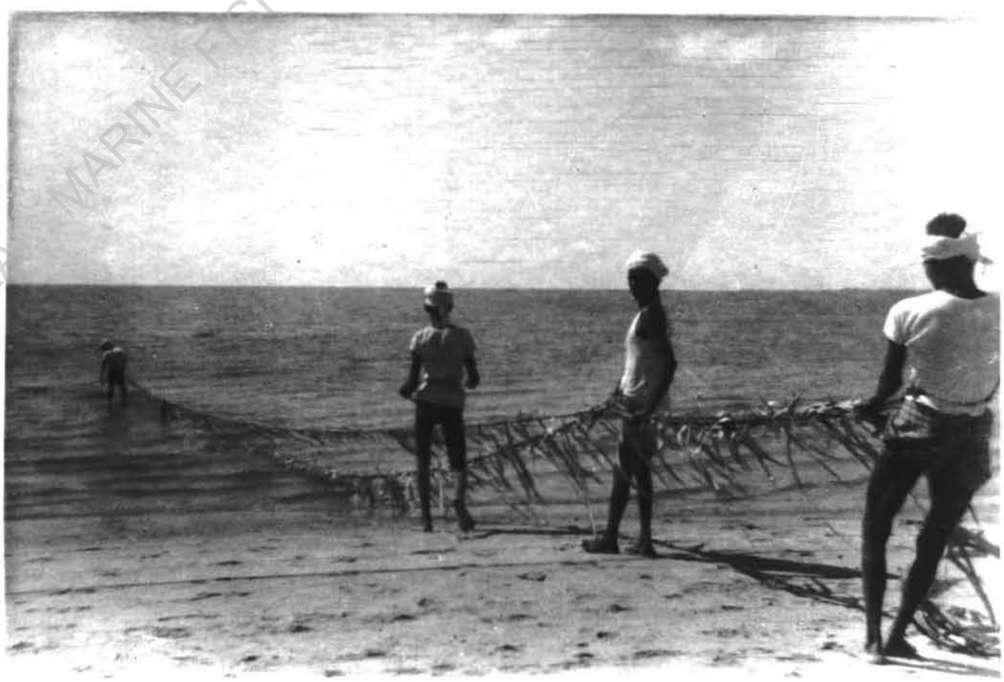
49

Photograph 1

Photograph 2

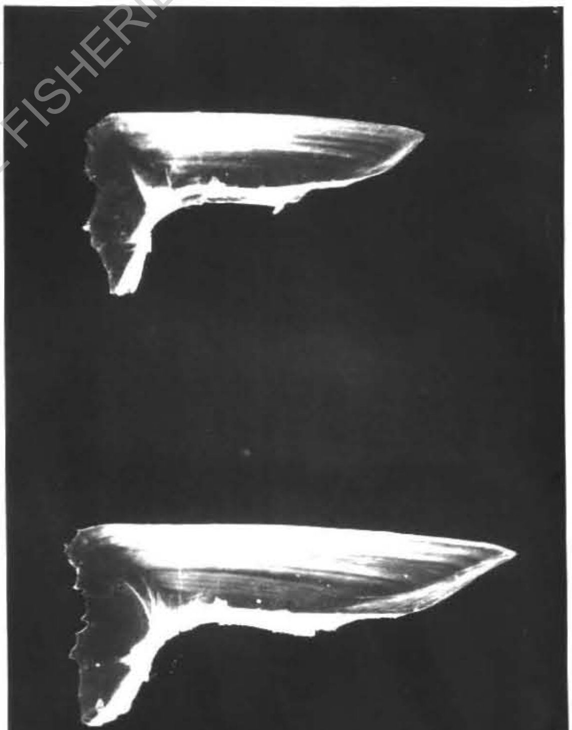
Photograph 3

Photograph 4



Photograph 5

Photograph 6



Photograph 7